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Treatment of Primary Effluent by Rapid Infiltration

Boulder, CO

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TREATMENT OF PRIMARY EFFLUENT BY RAPID INFILTRATION

by

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Grant No. R803931-02-4

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Treatment performance of three rapid infiltration basins receiving primary treated municipal treated wastewater is evaluated and compared with a previous study in which secondary treated municipal wastewater was applied at the City of Boulder, Colorado, Sewage Treatment Plant. The prime objectives of the project are evaluation of the pretreatment provided, the hydraulic load to the soil, duration of wetting and drying cycles, and climatic influences on system performance. Two of the basins have unscarified beds while one has a bed surface constructed in a ridge and furrow arrangement. Year-round operation allowed evaluation of applied effluent and infiltrated water collected from underdrains during extreme climatic conditions. Economic comparison of wastewater alternatives were assessed to determine the economic feasibility of rapid infiltration systems.

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FOREWORD

The U.S. Environmental Protection Agency was established to coordinate the administration of major Federal programs designed to protect the quality of our environment.

An important part of the Agency's effort involves the search for information about environmental problems, management techniques, and new technologies through which optimum use of the Nation's land and water resources can be assured and the threat pollution poses to the welfare of the American people can be minimized.

The U.S. Environmental Protection Agency's Office of Research and Development conducts this search through a Nationwide network of research facilities. As one of these facilities, the Robert S. Kerr Environmental Research Laboratory is responsible for the management of programs including the development and demonstration of soil and other natural systems for the treatment and management of municipal wastewaters.

The rapid infiltration treatment process for land treatment of municipal wastewaters uses the unsaturated soil profile beneath infiltration basins as the treatment media. This project was designed to evaluate the treatment capability of the unsaturated soil profile at the Seventy-Fifth Street Wastewater Treatment Plant in Boulder, Colorado. This study was conducted during a year of pilot-scale operations where primary pretreated wastewater was applied to infiltration basins. A study conducted during the previous two years at the same site evaluated the treatment efficiency of applied secondary pretreated municipal wastewater. Comparison of data from the two studies indicated that the quality of renovated wastewater was as good for primary pretreated wastewater as it was for secondary. Results demonstrate that high rate systems can be cost effective alternatives for municipal sewage treatment at sites where conditions are favorable for high hydraulic loading.

This report contributes to the knowledge which is essential for the U.S. Environmental Protection Agency to meet requirements of environmental laws and enforce pollution control standards which are reasonable, cost effective, and provide adequate protection for the American public.

Clinton W. Hall

Clinton W. Hall
Director
Robert S. Kerr Environmental Research Laboratory

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ABSTRACT

The objective of this study was to assess the capability of a rapid infiltration system for upgrading primary effluent from a municipal wastewater treatment plant, and to compare the performance with that obtained earlier on secondary effluent. This was done by monitoring the influent and effluent quality variations at a rapid infiltration demonstration facility over a period of one year.

The rapid infiltration site consisted of three basins ranging in size from 0.19 hectares (ha) [0.47 acres (ac)] to 0.35 ha (0.87 ac). During the period of secondary effluent application, the three basins were loaded at nominal hydraulic loading rates of 30.5 meters/year (m/yr) [100 feet/year (ft/yr)], 12.2 m/yr (40 ft/yr), and 48.8 m/yr (160 ft/yr). These rates were altered during the primary effluent application period to 15.2 m/yr (50 ft/yr), 43.9 m/yr (144 ft/yr), and 36.6 m/yr (120 ft/yr). The applied wastewater percolated through 0.3 - 0.9 m (1 - 3 ft) of sandy loam and 1.5 - 1.8 m (5 - 6 ft) of gravelly sand before being collected in an underdrain system.

Although the applied primary effluents represented a very weak sewage, the nature of the wastewater and altered hydraulic load allowed for a significant addition to data obtained during a previous period of secondary effluent application.

In general, the basins operated well during the entire period of primary effluent application. Many of the trends observed in the data served to reinforce observations made in previous years. Hydraulic response was somewhat improved during the primary study despite increased solids loading. Additionally, a seasonal effect on infiltration rates was observed, with the highest rates occurring during the warmest months. The pattern of nitrogen removal was not significantly altered by the change to primary effluent. As in previous years, a significant leakage of ammonium occurred during the winter months. The pattern of nitrate discharge was also unchanged from previous years, with low nitrate levels in the winter and slug discharges during the spring. All three basins demonstrated good organic removals throughout the period of primary effluent application. Effluent values for chemical oxygen demand (COD) were generally in the 8 - 20 milligrams/liter (mg/ℓ) range for both study periods. Renovated water phosphate levels seldom exceeded 1.0 mg/ℓ during the primary study. This pattern of leakage seemed to be a result of low phosphorus loadings and several long rest periods. Bacterial removals in the basins were excellent, with fecal coliform removals generally in excess of 99 percent. Observed removals were less than 99 percent in only four of 30 evaluations. Concentrations of selected salts typically increased through the basins; however,

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by March, 1979, Basins 2 and 3 had achieved an equilibrium condition with respect to salt additions. Basin 1 made no such move toward equilibrium, and continued to add significant amounts of calcium to the percolating water.

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SECTION 1

INTRODUCTION

The 1972 amendments to the Federal Water Pollution Control Act established a national goal: that the discharge of all pollutants into navigable waters be eliminated by 1985. The amendments also established a grants program to assist municipalities in meeting the goal. In the original form, the amendments required that alternative waste management techniques be evaluated prior to the approval of any grant. Subsequent revisions to the Environmental Protection Agency (EPA) grants regulations require that land treatment be considered and used if it is the most cost-effective alternative. This requirement has given new impetus to the search for energy efficient alternatives for the recovery and recycle of wastes and pollutants.

The 1972 amendments also required the application of the best practicable waste treatment technology (BPWTT) by July 1, 1983. This implied a universal application of tertiary treatment to remove harmful wastewater constituents. In the past, high technology in-plant tertiary processes have generally been used to achieve this end. However, the recent changes in the regulations have increased the probability that land treatment will qualify as BPWTT.

Historically, land treatment systems have been considered acceptable only for tertiary treatment or secondary effluent disposal. This fact is reflected in the laws of many states which require that conventional secondary treatment be provided prior to land application of wastewater. It was the purpose of this project to demonstrate that a rapid infiltration system is capable of providing cost effective secondary and tertiary treatment in a single treatment step. The treatment is provided by a combination of physical, chemical, and biological processes within the soil.

The system evaluated in this study was operated from July, 1976 to June, 1978 using unchlorinated secondary effluent as the influent water. During the final phase of this project, from September, 1978 to September, 1979, the water applied was unchlorinated primary effluent. The analytical program conducted in support of this effort was designed to permit comparison of system performance for the two different qualities of applied water.

SECTION 2

CONCLUSIONS

The rapid infiltration system was shown to be capable of providing a high quality renovated water with minimum pretreatment ahead of the rapid infiltration basins.

The infiltration rates on the rapid infiltration basins were higher when primary effluent was applied to the system than when secondary effluent served as the influent water. This occurred despite higher suspended solids loads in all of the basins when primary effluent was applied, and a higher hydraulic loading rate in one of them. It has been postulated that more rapid rates occurred with primary effluent because the solids were collected at the biologically active surface and degraded more rapidly than the suspended solids in secondary effluent.

The application of primary effluent to rapid infiltration basins did not produce any operational or aesthetic difficulties during a one year operational period at the Boulder site. The only observed difference between the application of primary and secondary effluents was an increased rate of plant growth in the basins during the period of primary effluent application.

The organic concentration, as measured by the chemical oxygen demand (COD), was essentially the same in the renovated water when either primary effluent or secondary effluent was applied to the basins.

The basins demonstrated the capability for achieving a consistently low level of phosphorus in the product water when the rate of phosphorus application to the rapid infiltration system was consistent with the rate of the long term removal mechanisms.

With the basin loading schedule practiced in this study, most of the nitrogen applied to the basins was oxidized by nitrification and discharged as nitrate nitrogen in the renovated water. As a result, the nitrate concentrations in the renovated water occasionally exceeded the acceptable nitrate levels for drinking water.

The basins provided major reductions in the concentration of coliforms in the unchlorinated primary effluent which was applied to the rapid infiltration system. However, the concentrations were still significant after passage through the basin soil profile. As such, disinfection would be required in Colorado prior to discharge into streams intended for primary contact recreation.

SECTION 3

RECOMMENDATIONS

From the observations which have been made during the course of this study, the following recommendations seem appropriate:

At the beginning of the study involving primary effluent, the hydraulic loading rates were reduced well below what they had been during the period of secondary effluent application. This was done because it was anticipated that basin fouling would be a problem with the lower quality of applied water. In light of the results of this study, it appears that the basins would be capable of treating primary effluent at a substantially higher hydraulic rate. It is recommended that a continuation study be performed to investigate the impact of increased loadings on both the hydraulic and treatment performance of the basins.

With the loading sequence practiced in this investigation, most of the applied nitrogen was discharged from these beds as nitrate. Other investigators have demonstrated that substantial denitrification can be achieved in rapid infiltration systems if the loading sequence is appropriately managed. Modification of the loading sequence should be attempted at the Boulder facility for the purpose of maximizing the total nitrogen removal.

A study should be undertaken to identify the loading schedule which would provide the best combination of hydraulic loading and treatment performance in the ridge and furrow configuration. The aim of this effort should be to minimize the total land area requirements for providing this alternative application method.

SECTION 4

EXPERIMENTAL FACILITIES AND PROCEDURES

The demonstration rapid infiltration system at Boulder, Colorado, was originally constructed and operated to determine the adequacy of such a system as a means of providing tertiary treatment for the wastewaters of the City of Boulder. At the completion of the original tertiary treatment study phase it was decided that an alteration of the application water to primary effluent would provide valuable insight into the treatment capabilities of the rapid infiltration system. This primary effluent phase of the operation began in November, 1978 and extended to October, 1979. During this period the project was conducted jointly by the City of Boulder, EPA, and the University of Colorado.

SITE DESCRIPTION AND PHYSICAL FACILITIES

The rapid infiltration system under investigation was located on the site of the 75th Street Wastewater Treatment Plant in Boulder, Colorado. The 75th Street plant was situated on the south bank of Boulder Creek, approximately 9.7 kilometers (6 miles) from the foothills of the Rocky Mountains.

The climate of the Boulder area is semi-arid continental with cold, dry winters and warm, relatively dry summers. The mean annual temperature in Boulder is 11.2°C (52.1°F), with mean monthly temperatures reaching a high of 23.3°C (73.0°F) in July, and a low of 0.6°C (33.1°F) in January. Climatological data indicate that Boulder has a 152 day growing season which begins on May 9 (1). Average annual precipitation in Boulder is 0.47 meters (m) [18.4 inches (in.)], with the amount decreasing with distance from the foothills. As an example, Longmont, which is located at a distance of 16.1 kilometers (10 miles) east of Boulder, receives 38 percent less moisture on an annual basis. Mean monthly temperature and precipitation data for Boulder have been shown in Figure 1.

The rapid infiltration site was located in the Piedmont section of Boulder County. The surface soils in this section consisted of unconsolidated deposits of Quaternary age (2). These deposits were composed of loose sand, loose gravel, and clay underlain by bedrock of oceanic origin. The soils of the Piedmont section have been classified into several associations, with the soil at the rapid infiltration site falling in the Niwot-Loveland-Calkins association. These soils are characterized as shallow to deep, nearly level, somewhat poorly drained soils on low terraces and bottom lands.

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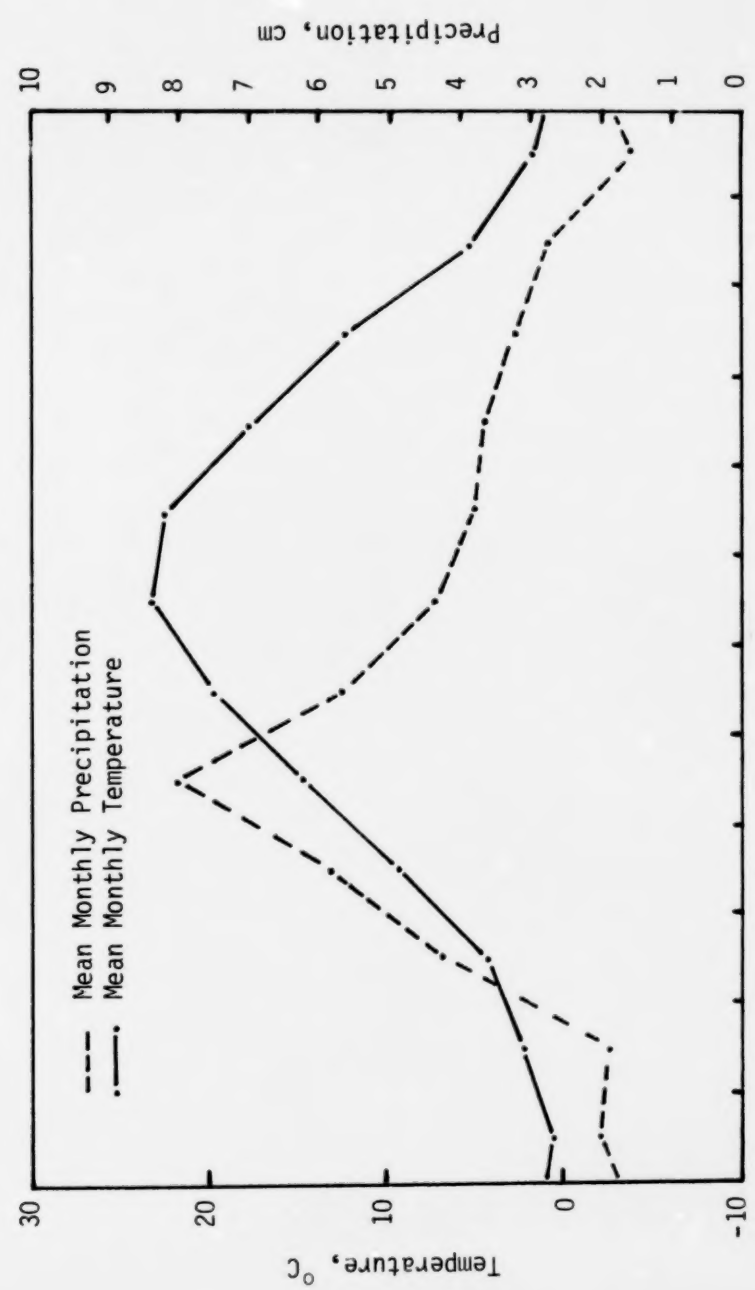

Figure 1. Mean monthly temperature and precipitation for Boulder, CO (1944-1973).

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In 1975, the consulting firm, CH_2M-Hill, performed a site investigation and found the soil at the site to be of the Niwot Series, consisting of loam, sandy loam or clay loam to a depth of 0.3 - 0.9 m [1 - 3 feet (ft)] (3). Below this layer, coarse gravel and sand extended to the bedrock formation. The bedrock at the site was found at a depth of 2.4 - 3.0 m (8 - 10 ft) and consisted of an impermeable layer of Pierre Shale. During this investigation, infiltration studies were performed at several locations adjacent to the rapid infiltration site. The Niwot Series soils were found to have low infiltration rates of 1.0 - 5.0 centimeters/hour (cm/hr) (0.4 - 2.0 in/hr) due to the existence of restrictive clay layers in the area. When the restrictive layers were removed, the infiltrative capacity of the soil was much improved. Ground water at the site was found at a depth of 0.9 - 1.5 m (3 - 5 ft) and flowed in a northeasterly direction toward Boulder Creek as indicated in Figure 2.

Construction of the three-basin rapid infiltration site was accomplished between December, 1975 and April, 1976. With the high ground water conditions at the site, it was considered necessary to isolate the system from the ground water to obtain an accurate evaluation of rapid infiltration treatment capabilities. As a result, the three basins were surrounded by a clay-core dike extending from 0.8 m (2.5 ft) above the ground surface to bedrock. In addition, a 0.8 m (2.5 ft) dike was constructed between the basins to contain the application water. In the original configuration, the site consisted of three basins (designated Basin 1, Basin 2, and Basin 3 from south to north) encompassing approximately 0.8 hectares (ha) [2.1 acres (ac)]. Figure 3 depicts the rapid infiltration system showing the individual basin sizes and the site layout. The underdrain system, which was installed to remove existing ground water and collect renovated water, is shown in Figure 4. It consisted of three pairs of 0.18 m (7 in.) perforated PVC pipe installed 2.4 - 3.0 m (8 - 10 ft) below the surface. These underdrains discharged into collecting manholes in each of the basins, and then into a central manhole.

With the results of infiltration tests performed at the site on October 9, 1975, operation was begun in May, 1976 at loading rates of 48.5 meters/year (m/yr) [159 feet/year (ft/yr)], 36.0 m/yr (118 ft/yr), and 53.7 m/yr (176 ft/yr) in Basins 1, 2, and 3, respectively. It soon became evident that Basins 2 and 3 were unable to function properly at these hydraulic loads. Efforts to improve the system performance by reduced hydraulic loading were not effective. As a result, in January, 1977 the upper 0.61 m (24 in.) of soil was removed from Basin 2, and the upper 0.46 m (18 in.) of soil was removed from Basin 3. The soil which was transferred from the basins consisted of a tight clay loam. Removal of this soil resulted in a substantially improved hydraulic response in both basins. Basin 2 was further modified in March, 1977 by the construction of a ridge and furrow system for distribution of the applied water. Nine furrows were constructed in the basin, each of which was 0.46 m (18 in.) deep and 85.4 m (280 ft) long. These furrows were separated by ridges 1.02 m (40 in.) wide and 1.93 m (76 in.) on center. A channel was added at each end of Basin 2 to allow for a rapid and even distribution of the applied water. Figure 5 shows the basin sizes and configurations after the modifications were completed.

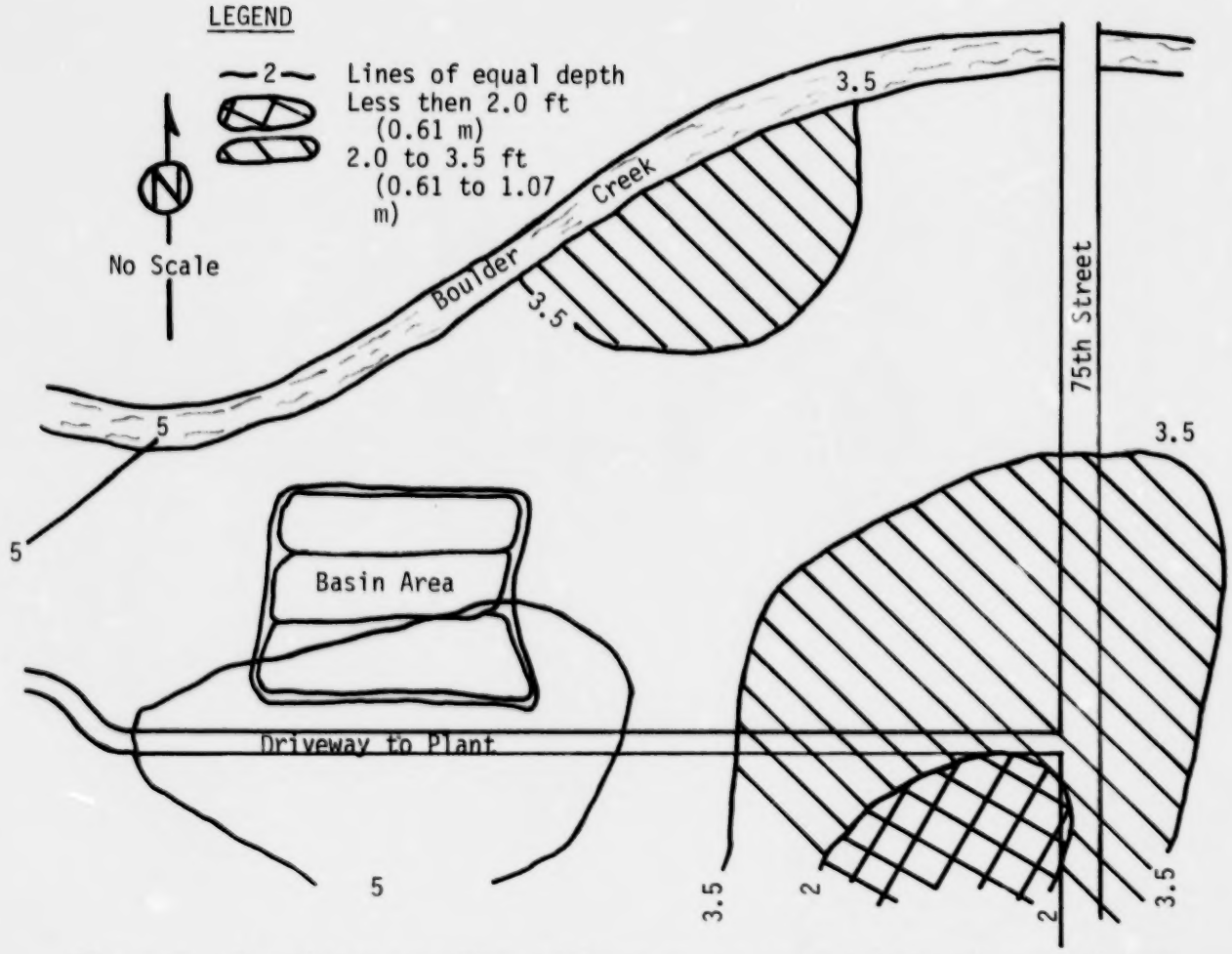

Figure 2. Ground water profiles adjacent to the rapid infiltration site (feet).

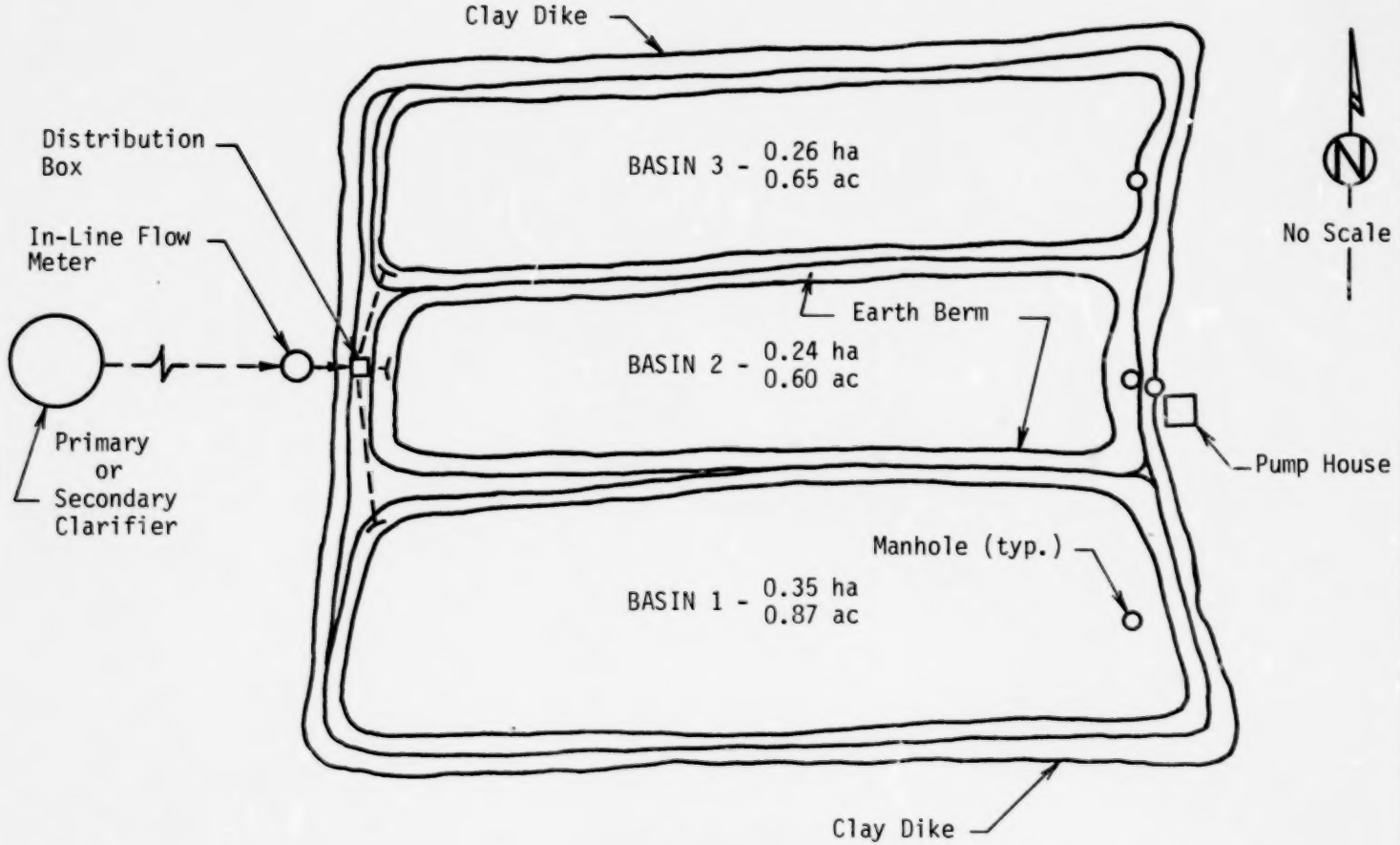

Figure 3. Original rapid infiltration system layout.

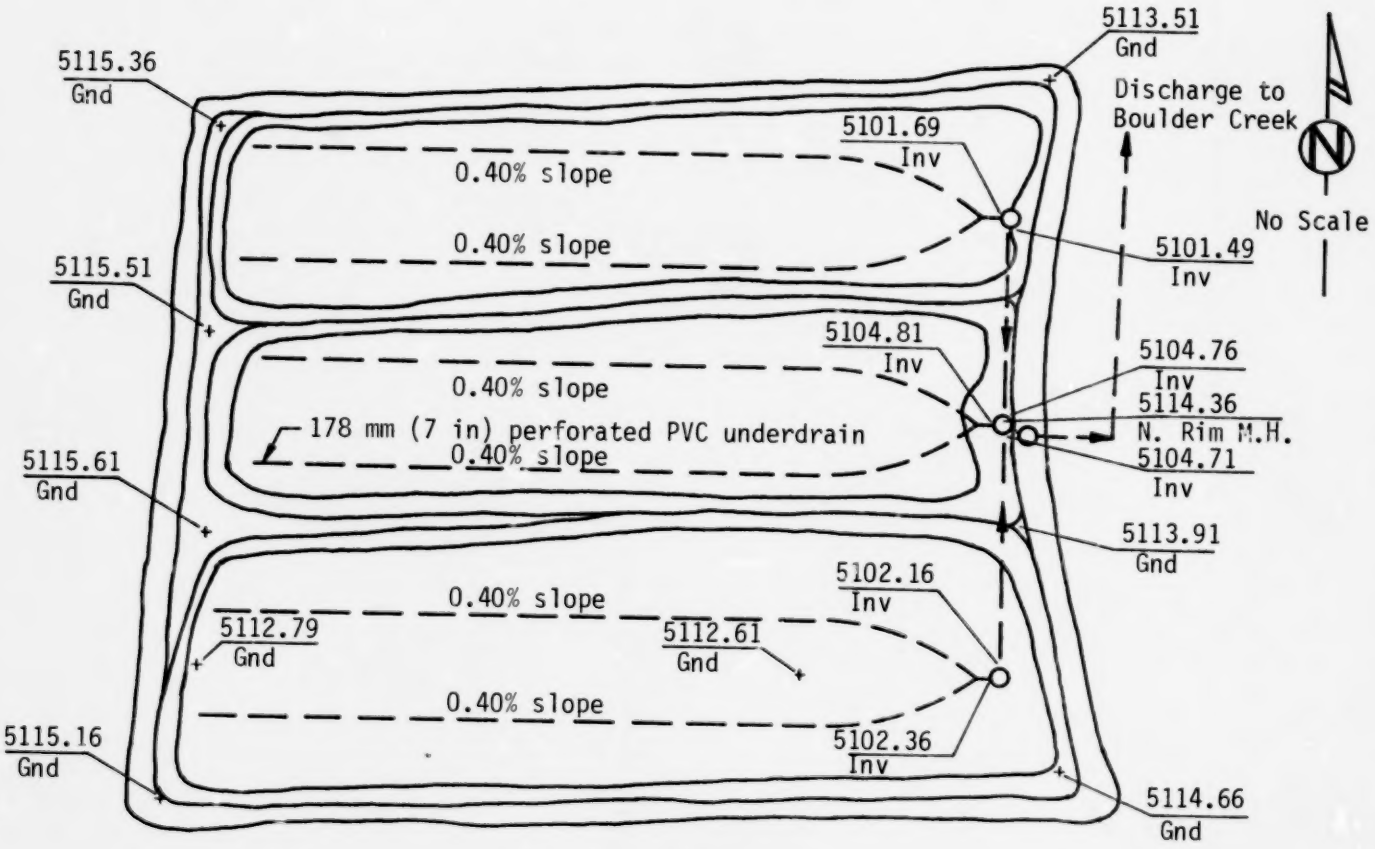

Figure 4. Basin underdrains. (Elevations in feet)

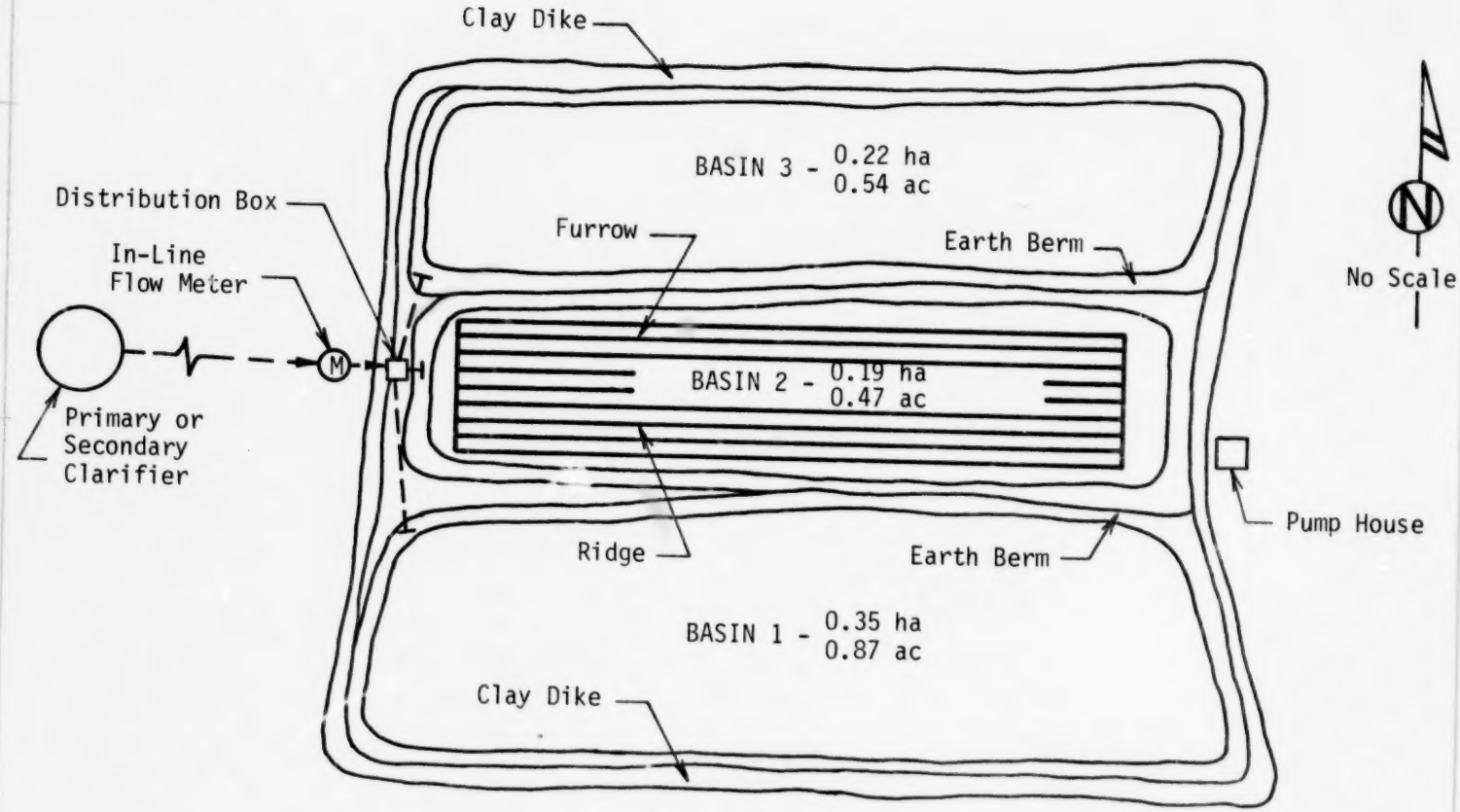

Figure 5. Modified basin configuration.

In addition to the major system facilities which have been described, several specific system components were utilized in the daily operation of the site. An electric blower was installed outside the central manhole and fitted with 3.05 m (10 ft) of flexible ducting. The ducting was channeled inside the manhole ladder to introduce fresh air to the bottom of the manhole and purge the area of hazardous gases. The central manhole itself drained into an adjacent wet well, from which the renovated water was pumped to Boulder Creek. This pumping was accomplished by a Worthington Pump with automatic water level controls.

BASIN LOADING AND SAMPLING

The basins were loaded with secondary effluent from May, 1976 to June, 1978 and with primary effluent from November, 1978 to October, 1979. These secondary and primary effluent wastewaters comprised the influent source to the rapid infiltration basins during the indicated study periods. The discharge from the rapid infiltration basins constituted the renovated water from the system. A summary of the analytical data collected during both the primary and secondary effluent studies has been included in Appendix A. A Worthington Pump, model 71011, was used to pump the basin influent through a 0.36 m (14 in.) PVC pipe to the rapid infiltration system. The PVC pipeline was approximately 305 m (1000 ft) in length and terminated in a distribution box at the west end of Basin 2. Figure 6 is a schematic diagram of the 75th Street plant showing the relationships of the various process units during the primary effluent study.

In an effort to provide for oxygen transfer into the soil, and maintenance of acceptable infiltration rates, each of the basins was loaded twice each week at 3.5-day intervals throughout the course of this study. During the period from October, 1976 to January, 1977 sampling and loading were accomplished in accordance with the schedule indicated in Table 1. From February, 1977 to June, 1978 the sampling and loading were accomplished in accordance with the schedule shown in Table 2. In November, 1978 the loading schedule was altered again to provide for an increased loading on Basin 2. Subsequent to this time, Basin 2 was loaded each Wednesday at 8:00 a.m., 12:00 noon, and 4:00 p.m. and each Saturday at 4:00 p.m. and 8:00 p.m. This basin was loaded at the indicated intervals to achieve a higher hydraulic loading, and yet avoid solids deposition on the ridges. In like manner, Basin 1 was loaded at 8:00 a.m. on Tuesday, and 5:00 p.m. on Friday. Basin 3 was loaded at 8:00 a.m. on Thursday and 5:00 p.m. on Sunday. The elapsed time between loading and sampling remained the same during the primary study as it had been during the February, 1977 to June, 1978 period.

As indicated earlier, the loading rates of the basins were varied early in the tertiary treatment study in an attempt to compensate for poor hydraulic response. Basin 1 maintained acceptable infiltration rates throughout the study, and was loaded at a constant rate of 30.5 m/yr (100 ft/yr) from October, 1976 to June, 1978. When primary effluent was applied to the surface of Basin 1, this rate was reduced to 15.2 m/yr (50 ft/yr) for the period November, 1978 to October, 1979. Basin 2 was loaded with secondary effluent at a rate of 12.8 m/yr (42 ft/yr) from April, 1977 to

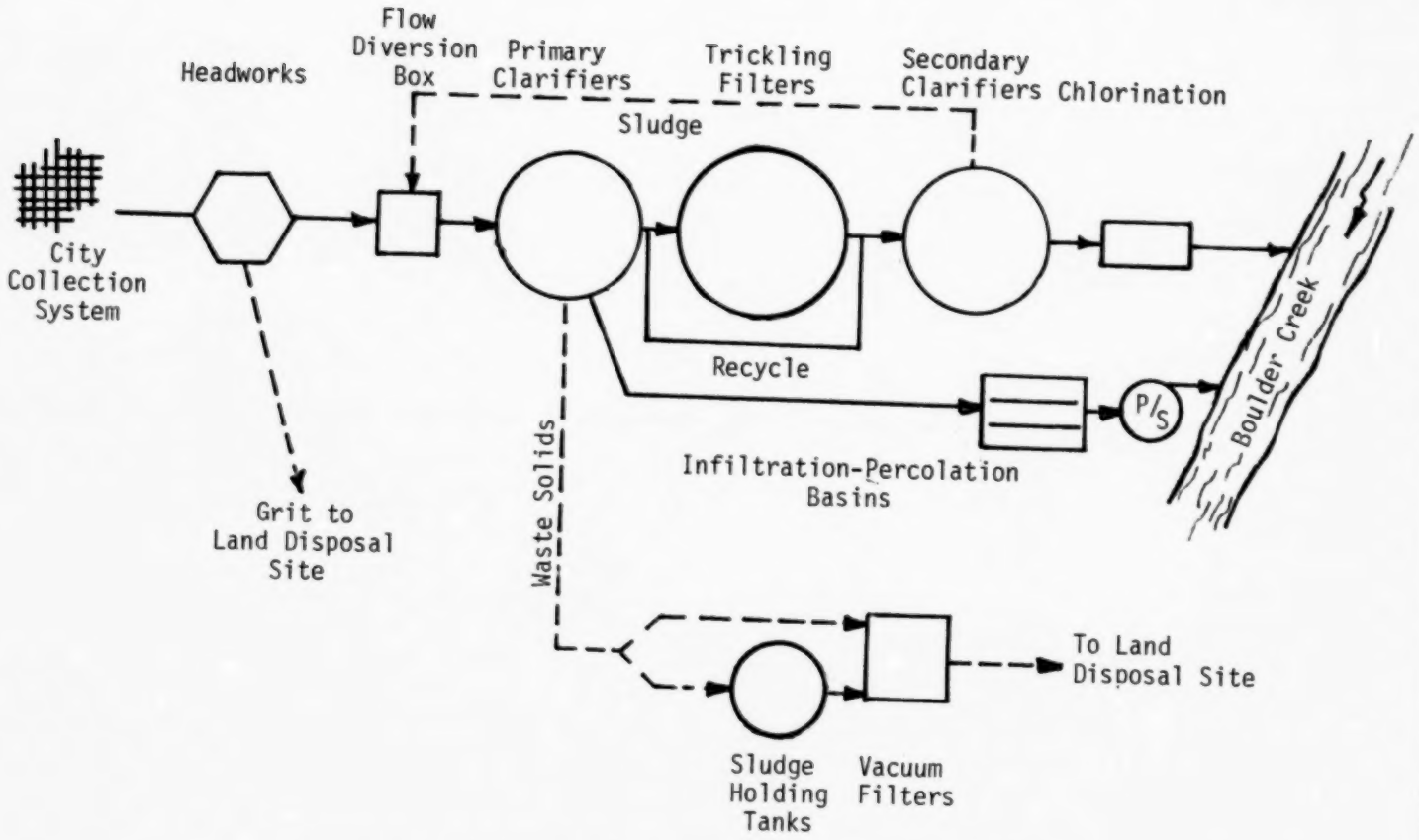

Figure 6. Schematic of Boulder wastewater treatment plant.

TABLE 1. LOADING AND SAMPLING SCHEDULE
(October 1976 to January 1977)

Day	Time	Basin 1	Basin 2	Basin 3
Monday	8:00 a.m.	Load Basin Measure Flow Sample Renovated Water		
	9:00 a.m.	Measure Flow Sample Influent Sample Renovated Water		
	11:00 a.m.	Measure Flow Sample Renovated Water		
	2:00 p.m.	Measure Flow Sample Renovated Water		
	8:00 p.m.	Measure Flow Sample Renovated Water		
Tuesday	8:00 a.m.	Measure Flow Sample for Complete Analysis	Load Basin Measure Flow Sample Renovated Water	
	9:00 a.m.		Measure Flow Sample Influent Sample Renovated Water	
	11:00 a.m.		Measure Flow Sample Renovated Water	
	2:00 p.m.		Measure Flow Sample Renovated Water	
	8:00 p.m.	Measure Flow Sample Renovated Water	Measure Flow Sample Renovated Water	
Wednesday	8:00 a.m.	Measure Flow Sample Renovated Water	Measure Flow Sample for Complete Analysis	Load Basin Measure Flow Sample Renovated Water
	9:00 a.m.			Measure Flow Sample Influent

(continued)

TABLE 1 (continued)

Day	Time	Basin 1	Basin 2	Basin 3
				Sample Renovated Water
	11:00 a.m.			Measure Flow Sample Renovated Water
	2:00 p.m.			Measure Flow Sample Renovated Water
	8:00 p.m.	Measure Flow Sample Renovated Water	Measure Flow Sample Renovated Water	Measure Flow Sample Renovated Water
Thursday	8:00 a.m.		Measure Flow Sample Renovated Water	Measure Flow Sample for Complete Analysis
	7:00 p.m.	Load Basin		
	8:00 p.m.		Measure Flow Sample Renovated Water	Measure Flow Sample Renovated Water
Friday	8:00 a.m.			Measure Flow Sample Renovated Water
	7:00 p.m.		Load Basin	
	8:00 p.m.			Measure Flow Sample Renovated Water
Saturday	7:00 p.m.			Load Basin

TABLE 2. LOADING AND SAMPLING SCHEDULE
(February, 1977 to June, 1978)

Day	Time	Basin 1	Basin 2	Basin 3
Tuesday	8:00 a.m.	Load Basin Measure Flow Sample Renovated Water		
	9:00 a.m.	Measure Flow Sample Influent Sample Renovated Water		
	12:00 noon	Measure Flow Sample Renovated Water		
	4:00 p.m.	Measure Flow Sample Renovated Water		
	8:00 p.m.	Measure Flow Sample Renovated Water		
Wednesday	8:00 a.m.	Measure Flow Sample for Complete Analysis	Load Basin Measure Flow Sample Renovated Water	
	9:00 a.m.		Measure Flow Sample Influent Sample Renovated Water	
	12:00 noon		Measure Flow Sample Renovated Water	
	4:00 p.m.		Measure Flow Sample Renovated Water	
	8:00 p.m.	Measure Flow Sample Renovated Water	Measure Flow Sample Renovated Water	
Thursday	8:00 a.m.	Measure Flow Sample Renovated Water	Measure Flow Sample for Complete Analysis	Load Basin Measure Flow Sample Renovated Water

(continued)

TABLE 2 (continued)

Day	Time	Basin 1	Basin 2	Basin 3
	9:00 a.m.			Measure Flow Sample Influent Sample Renovated Water
	12:00 noon			Measure Flow Sample Renovated Water
	4:00 p.m.			Measure Flow Sample Renovated Water
	8:00 p.m.	Measure Flow Sample Renovated Water	Measure Flow Sample Renovated Water	Measure Flow Sample Renovated Water
Friday	8:00 a.m.		Measure Flow Sample Renovated Water	Measure Flow Sample for Complete Analysis
	8:00 p.m.	Load Basin	Measure Flow Sample Renovated Water	Measure Flow Sample Renovated Water
Saturday	8:00 a.m.			Measure Flow Sample Renovated Water
	8:00 p.m.		Load Basin	Measure Flow Sample Renovated Water
Sunday	8:00 p.m.			Load Basin

June, 1978 and with primary effluent at 43.9 m/yr (144 ft/yr) from November, 1978 to October, 1979. Similarly, Basin 3 was loaded with secondary effluent at a rate of 48.8 m/yr (160 ft/yr) from February, 1977 to June, 1978 and primary effluent at 36.6 m/yr (120 ft/yr) from November, 1978 to October, 1979.

The basins were operated on a cyclic pattern throughout the study. A cycle usually consisted of six weeks of loading, followed by a drying period of one to four weeks. The variable drying period was required to accommodate the impact of climatic variations on the basin drying time. Typically, four weeks were required for drying during the winter, and one week for drying in the summer. When this time was not provided, it was physically impossible to scarify the beds. Once dry, Basins 1 and 3 were scarified with a tractor drawn spring tooth plow prior to being subjected to the next loading portion of the cycle. Basin 2, incorporating the ridge and furrow system, did not require scarification.

Samples of the basin influent were collected at the distribution box, and renovated water samples were collected at the central manhole. The renovated water was sampled at 0, 1, 4, 8, 12, 24, 36, 48, and 72 hours after loading. At each of these sampling times, a record was made of flow, temperature, and the dissolved oxygen concentration of the renovated water, as well as the depth of the applied wastewater remaining on the basin surface. Samples collected at these times were analyzed for nitrate, nitrite and ammonium nitrogen. A larger sample was collected at the 24 hour sample time and analyzed for the following constituents in the Water Quality Engineering Laboratory at the University of Colorado: total solids, suspended solids, phosphorus, COD, temperature, coliforms, alkalinity, pH, hardness, calcium, color, turbidity, and the nitrogen series. A summary of data for each of these constituents has been included in Appendix A.

Flow determinations were made in the central manhole by measuring the depth and dynamic head of the individual basin discharge pipes. Dynamic head was measured with a calibrated pitot tube. The measured depth was used to obtain a cross-sectional area of flow. From this information, the following expression was used to determine the flow rate:

$$Q = (2\ gha)^{0.5} \times A$$

where g = gravitational constant [32.2 ft/second^2 (sec^2)]

h = velocity head (ft)

a = pitot tube coefficient (0.8)

A = cross-sectional area of flow (ft^2)

Q = flow (ft^3/sec) = 35.31 x flow (m^3/sec)

The depth of the water on the surface of the basin was measured to obtain a basin infiltration rate. This rate was obtained by subtracting the final water depth from the initial water depth and dividing the result by the elapsed time between the two measurements. The resulting average infiltration rate has been reported in cm/hr.

SAMPLE PRESERVATION AND ANALYSIS

All samples which were collected, except those for temperature and dissolved oxygen analyses, were refrigerated at 4°C until the analyses were performed. Additionally, samples taken for COD, total Kjeldahl nitrogen (TKN), and ammonium determinations were acidified to a pH of less than 2 with concentrated sulfuric acid (H_2SO_4). Samples to be analyzed for nitrate and nitrite nitrogen were preserved with 40 mg/ℓ mercuric chloride ($HgCl_2$). Subsequent to January, 1979 all samples to be analyzed for nitrogen were preserved by acidification due to the hazards involved with the use of $HgCl_2$.

Temperature and dissolved oxygen determinations were made immediately after sampling. Temperature was determined with a mercury-filled centigrade thermometer calibrated to 1°C. The dissolved oxygen determinations were made using a Yellow Springs Instrument model 54A oxygen meter and the procedures outlined in Section 422 of the 14th Edition of Standard Methods (4). The instrument was air calibrated prior to each use.

COD determinations were made using the Dichromate Reflux Method as outlined in Section 508 of Standard Methods (4). Influent samples were analyzed for both total and soluble COD, while renovated water samples were only analyzed for total COD. Soluble COD concentrations were determined by filtering a portion of the sample through a 0.45 micron (μ) glass fiber filter. The filtrate was then analyzed for COD using the standard procedure.

TKN was determined using procedures detailed in Section 421 of Standard Methods (4). A 250 milliliter (ml) sample was carried through the digestion and distillation steps. Final measurement was accomplished by titration as outlined in Section 418B.4b-e of Standard Methods (4).

Ammonium determinations were made with the Orion Research electrode, model 95-10. Instructions provided with the electrode were followed. These instructions required the preparation of a new calibration curve for each set of samples.

Prior to January, 1977 nitrate determinations were made in accordance with Section 419D of Standard Methods (4). After that date, an automated procedure was utilized with the Technicon Autoanalyzer II. These procedures have been detailed in Section 605 of Standard Methods (4).

Similarly, before January, 1977 nitrite determinations were made in accordance with Section 420 of Standard Methods (4). After that date an automated procedure was adopted for nitrite as well. The Technicon Autoanalyzer II automated procedure for nitrites was as detailed in the operating instructions provided with the instrument.

Phosphorus determinations were made for both total and ortho-phosphorus. The preliminary digestion step for the total phosphorus determination was made using the Persulfate Digestion Method detailed in Section 425C of Standard Methods (4). Final color development was accomplished using the Stannous Chloride Method detailed in Section 425E of Standard Methods (4). Final Phosphorus determinations were made by measuring transmittance with a Bausch and Lomb Spectronic 70 spectrophotometer. During the period from January, 1978 to December, 1978, final phosphorus determinations were made with an automated method utilizing the Technicon Autoanalyzer II. This procedure was a modification of the Ascorbic Acid Method detailed in Section 606 of Standard Methods (4).

Alkalinity and pH determiantions were made with a Radiometer Automatic Titrator and pH meter. Alkalinity was determined by potentiometric titration to a pH of 4.8. This procedure has been detailed in Section 403 of Standard Methods (4).

Both calcium and hardness were determined by the EDTA Titrimetric Method. Prior to each use, the EDTA solution was standardized against a known calcium solution. Procedures for these determinations were as found in Sections 306C and 309B of Standard Methods (4).

During the secondary effluent application portion of this investigation, solids determinations were made by methods that varied somewhat from those described in Standard Methods (4). Suspended solids were determined by a modified process described by Harada and his co-workers (5). Total solids were determined by drying evaporating dishes for one hour at 103°C after which they were cooled in a desiccator for 30 minutes. At the end of the cooling period, the dishes were weighed for tare weight and filled with 100 ml of sample. The sample was evaporated on a hot plate, after which the evaporating dish was placed in a desiccator to cool for 30 minutes. At the conclusion of this cooling period a final weight was obtained.

During the primary effluent phase of the study, total solids and total fixed solids were determined in accordance with the procedures detailed in Section 208 of Standard Methods (4). Suspended solids were determined using a slight modification of the procedure in Section 208D of Standard Methods (4). This modification entailed preparing Gooch crucibles by drying at 550°C as in Section 208A. This modification was instituted to make the procedure compatible with the fixed suspended solids determination accomplished on the same samples.

Fecal coliform densities were determined using the membrane filter procedure described in Section 909C of Standard Methods (4). This determination was typically made twice per cycle with the results reported as fecal coliforms/100 ml.

Color determinations were made by the visual comparison method described in Section 204A of Standard Methods (4).

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Turbidity determinations were accomplished with a Hach 2100 Turbidimeter. The instructions provided with the instrument were followed, with the results reported in nephelometric turbidity units.

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SECTION 5

PERFORMANCE OF THE RAPID INFILTRATION SYSTEM

This study was conducted to evaluate the performance of a rapid infiltration system receiving primary effluent as the applied water, and to compare the performance with that of the same system loaded with secondary effluent. Of special interest during the study were changes in operational characteristics and renovated water quality attributable to the nature of the applied wastewater and the different hydraulic loadings employed.

It is important to note that the change in the quality of applied water, and in the hydraulic loading rates, presented some difficulties in making a direct comparison of the treatment performance of the basins. As a result, a mass loading approach has been used to assist in the interpretation of results. The average mass loadings of four critical wastewater constituents have been presented in Table 3. The reduced data used to develop these loadings appear in Table 4. The reduced data represent average applied wastewater concentrations for comparable calendar months in different years. It is apparent from these data that the applied wastewater concentrations for the four constituents shown represent a weak sewage. The 75th Street Wastewater Treatment Plant treated very weak sewage during a portion of the year due to dilution of the sewage by ground water. This is graphically indicated in Figure 7, which is a plot of composite plant data for flow and COD. Increasing plant flow during the spring and summer months was associated with a significant drop in raw wastewater strength and resulted in a corresponding drop in the strength of the water applied to the rapid infiltration basins. Another factor contributing to the relatively low wastewater strength was the basin loading time utilized during the study. The early morning loading and sampling time was chosen to facilitate an evaluation of the hydraulic response of the basins, and monitoring of the renovated water constituents which varied in concentration with time after loading. The peak flow of renovated water generally occurred 12 hours after loading. A wastewater strength survey at the treatment plant showed the primary effluent strength during the morning loading/sampling period to be approximately 60 percent of the daily average.

HYDRAULIC RESPONSE

It is important to the long-term operation of a rapid infiltration system that the infiltration rate be maintained within acceptable limits. Several interrelated factors combine to establish an overall infiltration rate. Site characteristics, management practices, and wastewater characteristics have all been implicated in this respect. The hydraulic focus of

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TABLE 3. AVERAGE WASTEWATER CONSTITUENT LOADING RATES
kilograms/hectare/week (kg/ha/wk)

	Hydraulic Loading[a]	Basin	TKN	NH_4^+-N	PO_4-P	COD	SS
Nov. 76 - Sept. 77 Secondary	12.8 (42)	2	28.1	16.1	12.7	158.4	26.9
	30.5 (100)	1	84.2	53.8	34.7	454.3	103.7
	48.8 (160)	3	122.4	62.6	48.9	679.7	167.7
Nov. 78 - Sept. 79 Primary	15.2 (50)	1	37.0	24.0	10.3	378.0	147.7
	36.6 (120)	3	84.6	54.3	25.9	860.6	304.2
	43.9 (144)	2	108.4	68.9	25.4	1133.4	366.8

[a]Nominal hydraulic loading rate in m/yr (ft/yr).

TABLE 4. AVERAGE WASTEWATER CONSTITUENT CONCENTRATIONS (mg/ℓ)

	Basin	TKN	NH_4^+-N	Total PO_4-P	COD	SS
Nov. 76 - Sept. 77 Secondary	1	14.4	9.2	6.0	77.8	17.8
	2	11.5	6.6	5.2	64.6	10.9
	3	13.1	6.7	5.2	72.5	17.9
Nov. 78 - Sept. 79 Primary	1	12.8	8.3	3.5	131	50.8
	2	12.9	8.2	3.2	135	43.6
	3	12.0	7.7	3.7	122	42.9

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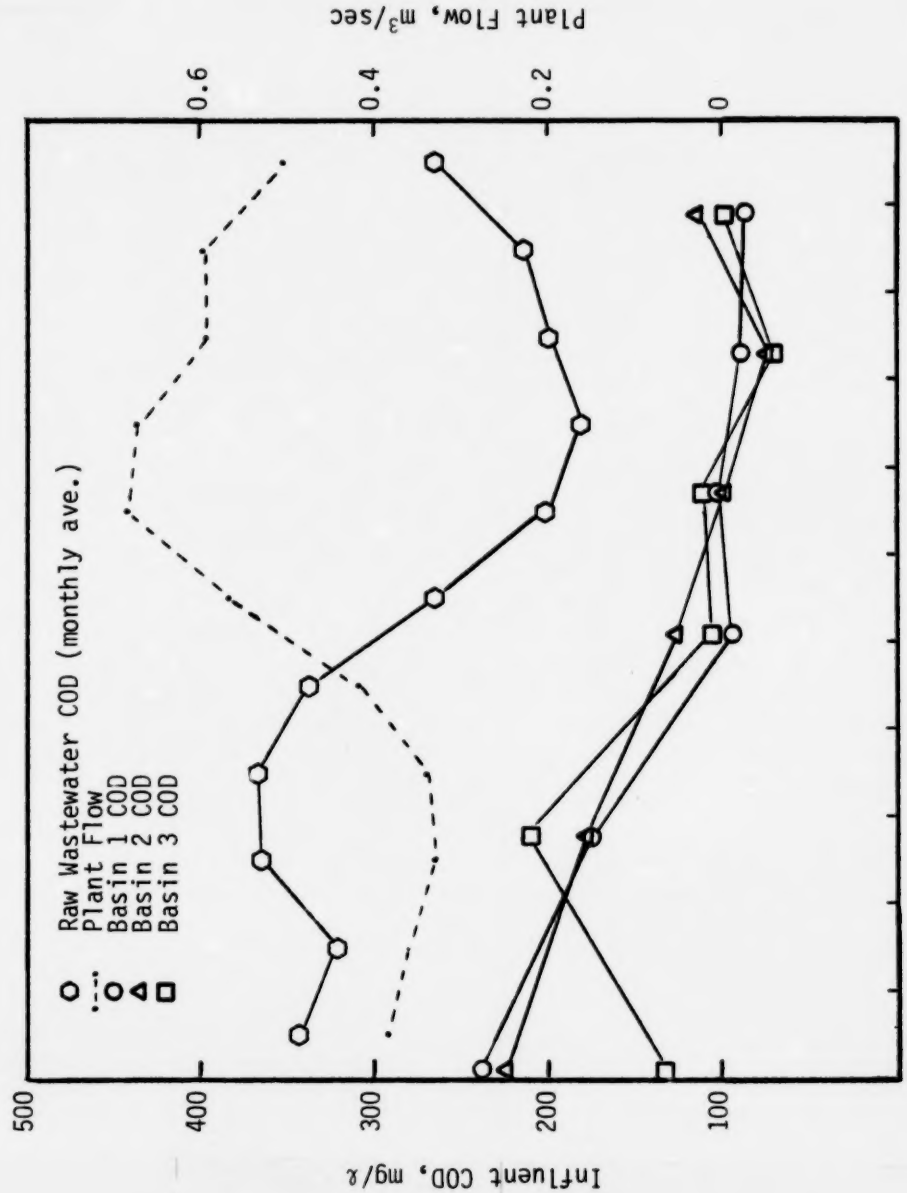

Figure 7. COD variation of applied wastewater.

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this rapid infiltration study was directed at evaluating the effects of primary effluent quality on infiltration rates.

During the course of the Boulder project, the infiltrative capacity of all three basins was measured with both secondary effluent and primary effluent applied to the basins. Infiltration rates for secondary effluent were measured from February 8, 1977 through July 7, 1977. Comparable infiltration rates for primary effluent were measured from April 3, 1979 through October 4, 1979. The results of these investigations have been summarized in Table 5. These data indicate that all three basins were able to maintain acceptable rates of infiltration during the primary effluent study. Average weekly infiltration rates have been presented in Table 5, with the cycle averages plotted for each cycle in Figure 8. Suspended solids concentrations and relative suspended solids loading rates varied considerably between the two phases of the study as can be seen in Figure 9 and Table 4. These were important factors in the interpretation of the data.

Based on the data compiled during the two phases of the Boulder infiltration studies, two trends can be identified: (1) the basins achieved higher infiltration rates when loaded with primary effluent than when loaded with secondary effluent; and (2) a seasonal pattern was noted in infiltration rates, with the highest rates occurring during the summer.

The first trend can be seen very clearly in Figure 8. The increased infiltration rates with primary effluent loading were noted in each basin, despite a higher suspended solids loading rate in every case. Several explanations for this type of response appear in the literature. Lance, Rice and Bouwer observed infiltration rates with primary effluent which were only slightly less than those for secondary effluent, despite a suspended solids loading of an order of magnitude greater (6). In their soil column studies, the primary effluent infiltration rate was measured at 0.73 cm/hr compared to a rate of 0.88 cm/hr for the secondary effluent. Lance et al. deduced from these results that the suspended solids in primary effluent had less impact in reducing infiltration rates because they were degraded more rapidly in the soil than the suspended solids present in secondary effluent.

Daniel and Bouma offered a somewhat different explanation for this pattern (7). They found the suspended particle size to be important to the nature of soil clogging. The smaller suspended solids which characterize secondary effluents could more easily penetrate the top soil and form subsurface blockages. The larger suspended solids which characterize primary effluent tended to remain on the biologically active soil surface where they were desiccated and decomposed.

The second trend noted in the data, the seasonal pattern of infiltration rates, can also be seen in the data of Figure 8. This pattern is likely impacted by the change in rates of biological decomposition which accompanies changes in temperature. In the colder winter months, the rate of removal of the deposited organic solids would likely be slowed by the reduced rate of biological activity. Additionally, the increased viscosity of the applied wastewater undoubtedly played a part in lowering the rate of infiltration. Whatever the mechanism, the seasonal pattern of infiltrative capacity is an

TABLE 5. SUMMARY OF INFILTRATION RATES

Loading Date	M^3 Loaded	Infiltration Rate (cm/hr)	Loading Date	M^3 Loaded	Infiltration Rate (cm/hr)	Loading Date	M^3 Loaded	Infiltration Rate (cm/hr)
	Basin 1	(Secondary Effluent)		Basin 2	(Secondary Effluent)		Basin 3	(Secondary Effluent)
2-8-77	1024	0.99	4-13-77	255	9.5	2-10-77	1262	3.2
2-15-77	1256	0.84	4-20-77	273	2.2	2-17-77	997	0.58
2-22-77	1158	0.84	4-27-77	—	2.4	2-24-77	1330	0.58
3-1-77	1166	0.64	5-4-77	263	2.5			
3-8-77	1193	0.48	5-18-77	261	4.8	Cycle Average		1.5
3-15-77	1240	0.48						
			Cycle Average		4.3	4-14-77	1220	0.61
Cycle Average		0.71				4-21-77	984	0.56
			6-1-77	238	5.1	5-12-77	1191	2.3
4-12-77	817	2.5	6-8-77	320	4.8	5-19-77	1080	1.1
4-19-77	1146	0.38	6-15-77	248	5.4			
5-10-77	1195	2.9	6-22-77	250	5.4	Cycle Average		1.1
5-17-77	957	0.71	6-29-77	525	3.3			
			7-6-77	253	5.1	6-2-77	1186	2.3
Cycle Average		1.6				6-9-77	1160	1.9
			Cycle Average		4.8	6-23-77	946	1.6
5-31-77	986	2.8				6-30-77	1169	1.4
6-7-77	1079	2.0				7-7-77	1147	1.2
6-14-77	1212	1.7						
6-21-77	1257	1.6				Cycle Average		1.7
6-28-77	1239	1.4						
7-5-77	1114	1.3						
Cycle Average		1.8						

(continued)

TABLE 5 (continued)

Loading Date	M^3 Loaded	Infiltration Rate (cm/hr) (Primary Effluent)
	Basin 1	
4-3-79	465	2.69
4-17-79	459	1.67
4-24-79	436	3.28
5-1-79	517	2.54
5-8-79	378	0.79
Cycle Average		2.19
5-22-79	378	2.74
5-29-79	382	2.97
6-5-79	432	2.92
6-12-79	412	3.38
6-19-79	444	3.18
6-26-79	469	2.74
Cycle Average		2.99
7-10-79	464	3.40
7-17-79	456	2.79
7-24-79	596	3.00
7-31-79	519	2.87
8-7-79	499	4.06
8-14-79	567	3.00
Cycle Average		3.19
8-28-79	498	3.43
9-4-79	435	3.58
9-11-79	510	3.56
9-18-79	448	4.22
9-25-79	472	5.11
10-2-79	468	1.91
Cycle Average		3.64

Loading Date	M^3 Loaded	Infiltration Rate (cm/hr) (Primary Effluent)
	Basin 2	
4-4-79	251	3.61
4-11-79	501	5.08
4-18-79	574	6.99
4-25-79	900	4.22
5-2-79	517	6.35
5-9-79	657	5.49
Cycle Average		5.29
5-23-79	471	7.37
5-30-79	540	5.89
6-6-79	161	4.60
6-13-79	789	6.02
6-20-79	922	8.13
6-27-79	122	8.00
Cycle Average		6.67
7-11-79	693	6.27
7-18-79	851	6.86
7-25-79	731	6.65
8-1-79	837	7.62
8-8-79	312	7.90
8-15-79	815	8.89
Cycle Average		7.37
8-29-79	616	8.59
9-5-79	831	6.22
9-12-79	881	8.41
9-19-79	839	6.88
9-26-79	572	7.62
10-3-79	287	6.78
Cycle Average		7.42

Loading Date	M^3 Loaded	Infiltration Rate (cm/hr) (Primary Effluent)
	Basin 3	
4-5-79	588	3.30
4-12-79	329	1.52
4-19-79	462	3.18
4-26-79	638	1.91
5-3-79	585	2.11
Cycle Average		2.40
5-24-79	648	2.92
5-31-79	632	2.39
6-14-79	457	2.54
6-21-79	657	2.79
6-28-79	628	2.77
Cycle Average		2.68
7-12-79	633	3.81
7-19-79	765	3.28
7-26-79	693	2.41
8-2-79	732	3.63
8-9-79	752	3.33
8-16-79	681	3.12
Cycle Average		3.26
8-30-79	851	3.35
9-6-79	681	2.44
9-13-79	762	1.88
9-20-79	731	2.34
9-27-79	672	2.11
10-4-79	718	2.18
Cycle Average		2.38

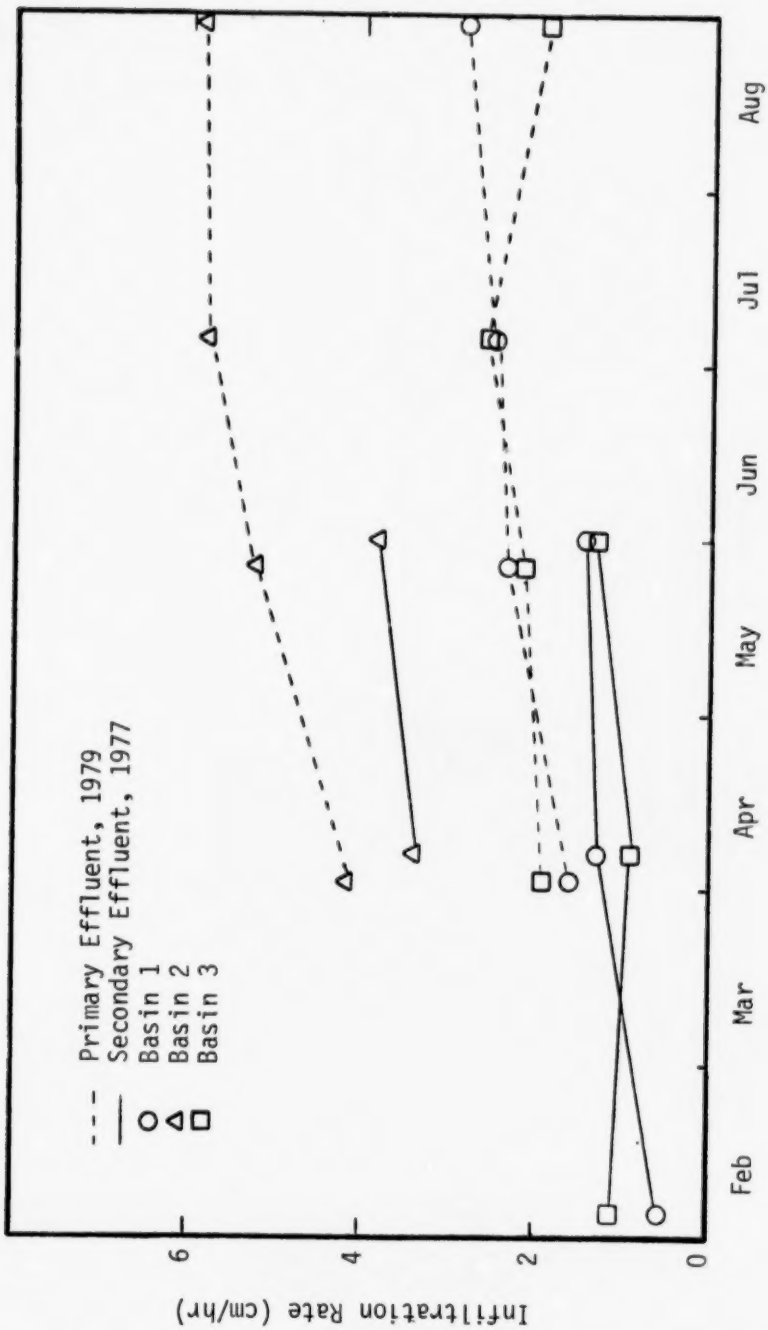

Figure 8. Variation of infiltration rates with time.

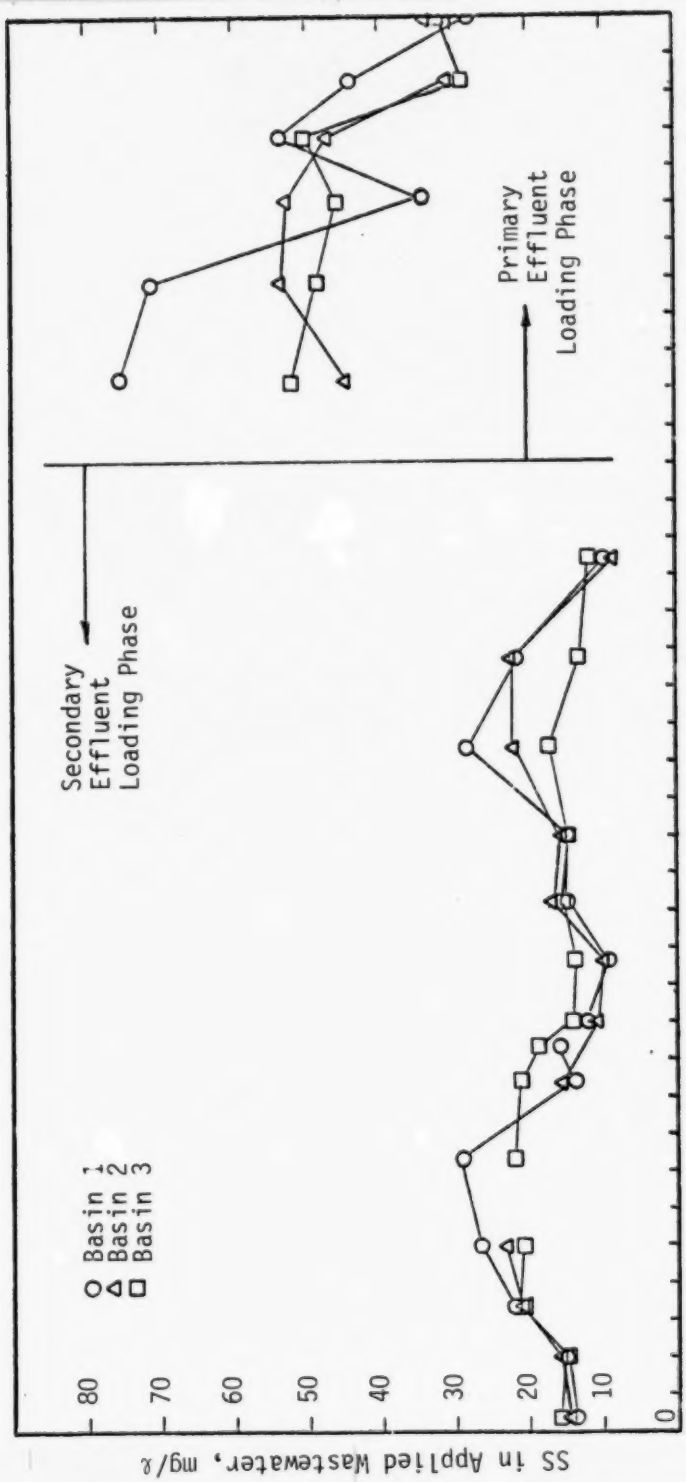

Figure 9. Suspended solids concentrations in applied wastewater.

item that should be considered in design of rapid infiltration systems since the rates varied seasonally by up to 50 percent in this study involving the application of primary effluent.

NITROGEN BEHAVIOR

The interpretation of nitrogen data in this type of study is complicated by the many nitrogen transformations which occur in soil systems. Based on the accumulated information provided through previous studies, it would appear that the major mechanisms of nitrogen removal from the rapid infiltration basins included: (1) leaching of ammonium to the ground water; (2) leaching of nitrate to ground water; and (3) transfer of nitrogen gas to the atmosphere. Evaluation of nitrogen removal by denitrification, volatilization, and fixation was difficult to assess. However, it is believed that the only mechanism capable of significant nitrogen removal from the liquid stream in a rapid infiltration system is the nitrification-denitrification sequence.

With the uncertainties involved in describing nitrogen removal from wastewater in rapid infiltration systems, the emphasis in this study was focused on characterizing those nitrogen forms remaining in the renovated water. The principal forms of nitrogen in the renovated water were nitrate and ammonium. Figure 10 and Figure 11 show cycle averages for these constituents during both the secondary effluent and primary effluent phases of the study. The weekly values used to calculate cycle averages were obtained by a flow weighting of the constituent concentrations at individual sampling times. The wegihting process consisted of developing weekly hydraulic discharge and mass flow curves for each basin. Integration of these curves provided an average flow and an average mass flow. The proportional average was obtained by dividing the average mass flow (mg/sec) by the average hydraulic flow (ℓ/sec).

From the data summarized in Figures 10 and 11, it is apparent that the rapid infiltration system at Boulder, Colorado was generally capable of producing a well nitrified renovated water. The application of primary effluent had no significant effect on the nitrogen quality of the renovated water.

Nitrate concentrations in the renovated water during the period of primary effluent application seemed to follow the trends established in previous years of operation. The winter operating cycle typically produced renovated water with the lowest nitrate concentrations when the renovated water temperatures ranged from 4°C to 6°C. Andersen and Boswell have shown that at these temperatures nitrification may be partially or completely suppressed, depending on the soil type (8). In March, 1979 the basins discharged a concentrated nitrate peak with the first spring loading. During this loading, the average renovated water nitrate concentrations for the three basins were 28.0 mg/ℓ, 31.8 mg/ℓ, and 28.7 mg/ℓ, respectively. The appearance of a spring nitrate peak also occurred during each of the previous two years of the study. This pattern of discharge has been well documented in the literature, and is generally attributed to the higher rate of

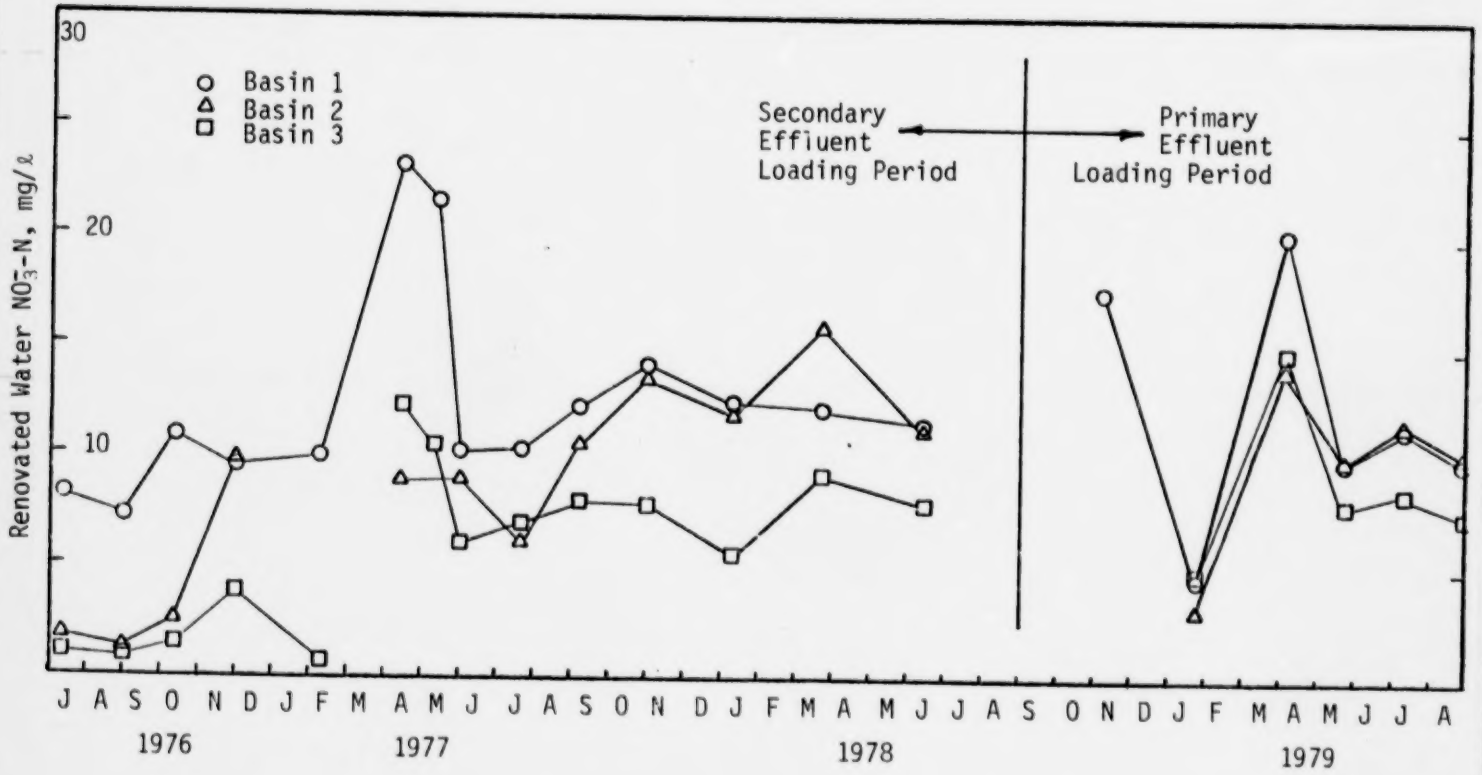

Figure 10. Renovated water nitrate nitrogen as a function of time.

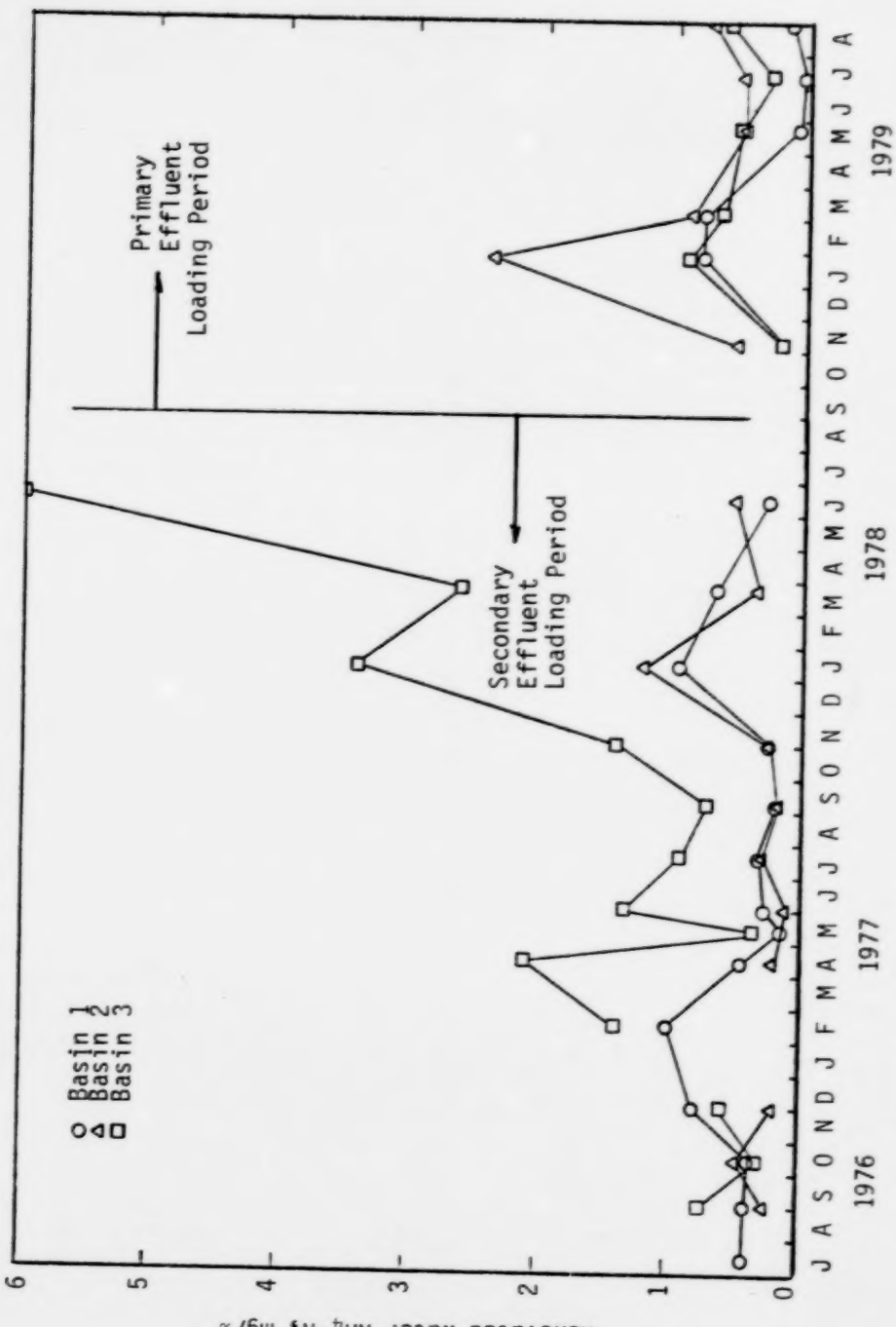

Figure 11. Renovated water ammonium nitrogen as a function of time.

nitrification brought on by increased temperatures.

Basin 1 demonstrated good ammonium removals throughout the study, with ammonium leakage levels of as low as 0.1 mg/ℓ ammonium nitrogen (NH_4^+-N) during the summer when primary effluent was being applied. The maximum ammonium leakage occurred during the cold winter months when nitrification was inhibited.

The seasonal ammonium trends noted for Basin 1 also held true for Basins 2 and 3. Ammonium leakage generally peaked in January and February, the period of coldest air and wastewater temperatures. The most notable exception to this trend was the pattern observed in Basin 3 between September, 1977 and June, 1978. During this period, the effluent ammonium nitrogen levels increased steadily from 0.71 mg/ℓ to 6.0 mg/ℓ. At this time, Basin 3 was receiving the heaviest mass ammonium loading of the three basins.

In an effort to evaluate the effect of the mass/hydraulic loading rate on ammonium leakage, influent and renovated water ammonium concentration levels were plotted on a log-probability format in Figure 12. These data were compiled for comparable calendar periods during each phase of the study. Data from Basin 1 were used for this evaluation because of the continuity of operation in this basin. These data show that the rapid infiltration system was very reliable in removing ammonium from both primary and secondary effluents. The data in Table 3 indicate that the hydraulic and mass loading rates during the primary effluent loading study were approximately one-half the rates applied during the secondary effluent phase of the study. These lower loadings are reflected in an average ammonium leakage level during the primary effluent loading period of about one-half that experienced when nitrogen was applied to the basin at the higher rate during secondary effluent application.

In rapid infiltration systems, the extent of ammonium leakage is dependent on the capacity of the soil to remove the organic and ammonium nitrogen from the applied wastewater. The capacity to adsorb and fix (permanent removal by incorporation into stable organics) ammonium is dependent upon soil characteristics, such as the cation exchange capacity and the organic content of the soil. Once an adsorption site is occupied by an ammonium ion, that ion must be fixed or nitrified before the site is available for removing other ammonium ions. Nitrate, the product of nitrification, is generally leached through the soil or converted to nitrogen gas, depending on conditions at the individual microsite. For effective long-term ammonium removal at a rapid infiltration site there must be an appropriate equilibrium established between the mass loading of ammonium and the number of available adsorption sites. If the number of ammonium ions applied in a loading exceeds the number of sites regenerated between loadings, increasing quantities of ammonium will be leached through the soil. On the other hand, if sites regenerated between loadings exceed the demand of the applied ammonium, ammonium removals in successive loadings will tend to be enhanced. A seasonal imbalance in this loading/regeneration sequence seemed to be the primary cause of the seasonal leakage of ammonium which was observed in this study. This imbalance was apparently caused by the temperature induced

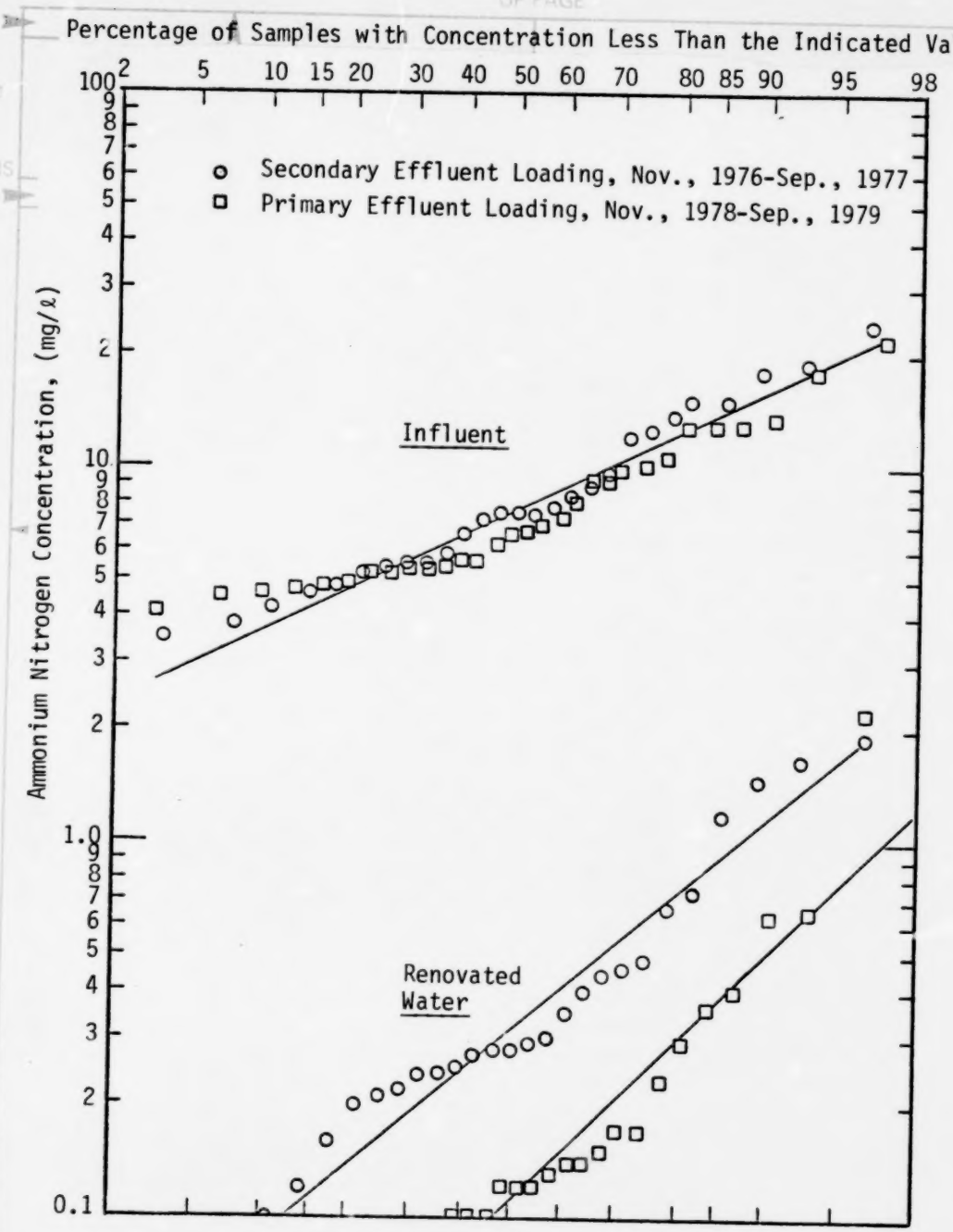
Percentage of Samples with Concentration Less Than the Indicated Value
2 5 10 15 20 30 40 50 60 70 80 85 90 95 98
Secondary Effluent Loading, Nov., 1976-Sep., 1977
Primary Effluent Loading, Nov., 1978-Sep., 1979
Ammonium Nitrogen Concentration, (mg/ℓ)
Influent
Renovated Water
100
10
1.0
0.1

Figure 12. Ammonium concentration variations.

slowing of nitrification. The increased ammonium leakage in Basin 3 during 1977 and 1978 graphically depicts the effect of excessive long term ammonium loading. When the loading situation was altered during the primary effluent phase of study with a 25 percent decrease in the ammonium loading rate, Basin 3 was able to operate successfully throughout the entire period of primary effluent application.

ORGANIC REMOVAL

The concentration of organic matter in primary effluent usually differs markedly from that in secondary effluents. However, as shown in Figure 7, the primary effluent applied to the rapid infiltration system in this study was somewhat weaker than typical primary effluent. Nevertheless, the response of the basins to different loads and a waste of different characteristics provided insight into the organic removal capabilities of rapid infiltration systems.

All three basins demonstrated good organic removal capability during the period of primary effluent application. This is indicated in Figure 13, which summarizes the percentage removal of total COD during the entire study. As seen in this figure, the basins demonstrated a slightly increased removal efficiency during the period of primary effluent application over that achieved when secondary effluent was applied. Thomas and Bendixen accounted for a similar phenomenon by noting differences in the nature of the applied organics (9). The most readily oxidized organic fraction is removed during secondary treatment leaving the more resistant fraction to be treated by the soil system. This results in a lower percentage of COD removal when secondary effluents are applied to the basins.

The renovated water COD concentrations have been summarized in Figure 14, which is a plot of the average COD for each loading cycle as a function of time. In reviewing these data, two distinct effluent COD peaks can be observed. The first occurred in February, 1977 during a plant upset, and the second in January, 1979. During both of these periods the COD levels in the influent to the basins were high and the wastewater temperatures were low. No similar peak occurred in the intervening winter. Data presented by Thomas and Bendixen have indicated that with other factors remaining constant, rapid infiltration systems are capable of achieving a fixed percentage of organic removal over a wide temperature range (9). This seems to implicate the high applied wastewater concentrations as the major contributing factor in the indicated COD peaks.

In addition to the COD peaks which have been noted, two trends were evident in the renovated water COD data. First, the renovated water COD concentrations seemed to parallel the influent COD concentrations; and, second, the basins with the highest hydraulic/mass loading rates tended to correspond to those with the highest COD concentrations in the renovated water.

In an effort to clarify the relative contributions of organic load, hydraulic load, and wastewater strength to renovated water quality, the influent and renovated water COD concentrations for the three basins have

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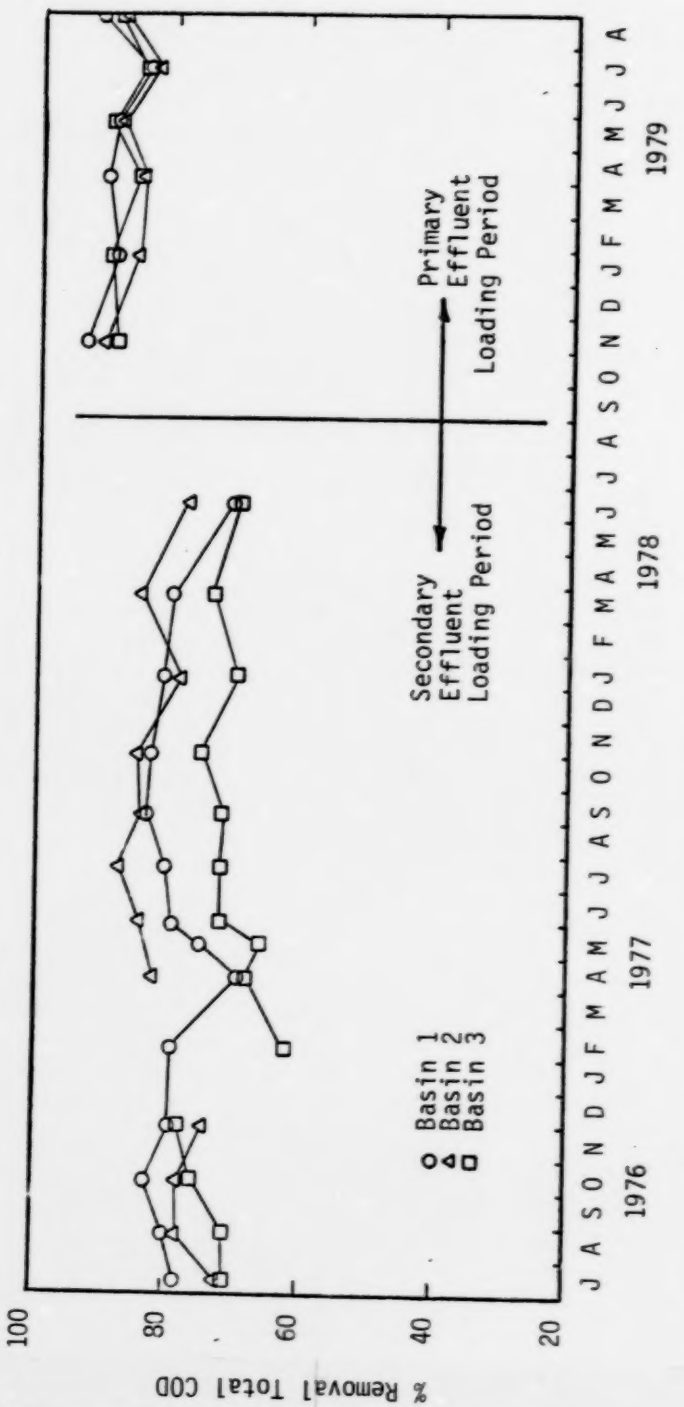

Figure 13. COD removal efficiency as a function of time.

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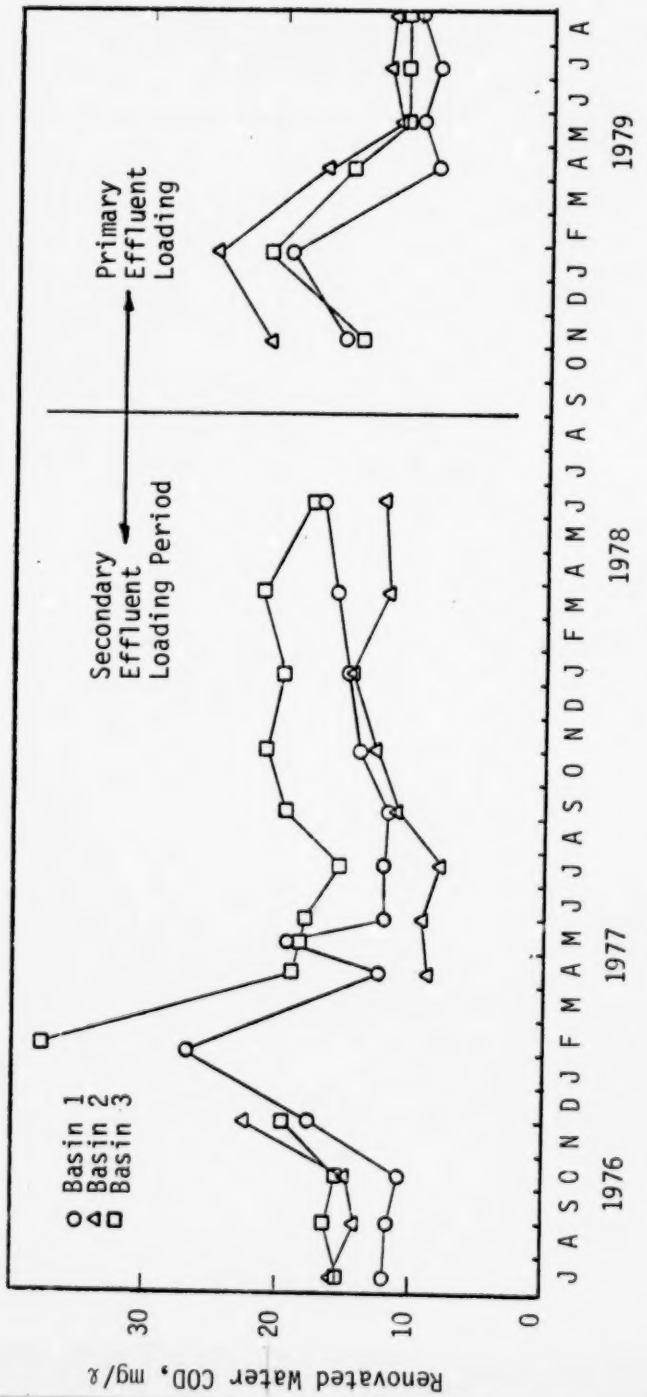
Renovated Water COD, mg/ℓ
0
10
20
30
Basin 1
Basin 2
Basin 3
Secondary Effluent Loading Period
Primary Effluent Loading
J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A
1976
1977
1978
1979

Figure 14. Renovated water COD as a function of time.

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been presented as log-probability relationships in Figures 15-17. These figures were developed from weekly influent and renovated water COD concentrations over a one-year period of secondary effluent application, and a one-year period of primary effluent application. The data seem to conform to a log-normal distribution.

Figure 15 indicates that Basin 1 produced a higher quality renovated water with respect to the organic pollutants during the primary effluent study, despite a higher concentration of organic material in the applied wastewater. However, Table 3 shows that the hydraulic load and organic load were both lower during the primary effluent loading phase of the study.

Figure 16 shows that the COD concentrations in the renovated water from Basin 2 increased during the primary effluent study by an amount similar to the decrease achieved in Basin 1. During the primary effluent study phase, the hydraulic loading and mass loading to Basin 2 were approximately three times the levels applied during the secondary effluent phase of the study.

The data from Basin 3 (Figure 17) demonstrated a decrease in renovated water COD during the primary effluent loading phase as compared to that observed during the secondary effluent loading phase. This pattern occurred under conditions of increased mass loading and decreased hydraulic loading when primary effluent was applied to the basin.

Based on the effects of mass loading and hydraulic loading seen in these data, the hydraulic loading seems to be the more important of the two loading parameters.

In their 1969 study, Thomas and Bendixen applied secondary effluent to one lysimeter and septic tank effluent to another. The secondary effluent lysimeter was loaded at one-half the organic load of the septic tank lysimeter and at a hydraulic load equal to that of the septic tank lysimeter. The organic content of the percolate was the same in both instances, implicating hydraulic load as the controlling factor. A final phase of the Thomas-Bendixen study involved the comparison of two lysimeters loaded at different rates with secondary effluent. One lysimeter had a hydraulic loading rate of 0.20 $m^3/day/m^2$ [5 gallons per day/foot^2 (5 gpd/ft^2)] and an organic loading rate of 89.7 kg/ha/day (80 lb/ac/day). The other lysimeter was loaded at 0.04 $m^3/day/m^2$ (1 gpd/ft^2) and 22.6 kg/ha/day (20 lb/ac/day). Equal fractions of the applied load were degraded by each lysimeter; however, the highly loaded lysimeter passed 30 percent of the applied load in the percolate, compared to only 11 percent for the low rate lysimeter. Once again, this observation would suggest that hydraulic loading, and the associated residence time of the water in the soil system, is a major factor dictating the renovated water quality of a rapid infiltration system.

The results of earlier studies, as well as data obtained from this study, seem to indicate that renovated water COD concentration in a rapid infiltration system is a function of the refractory/weakly absorbed organic concentration and hydraulic loading.

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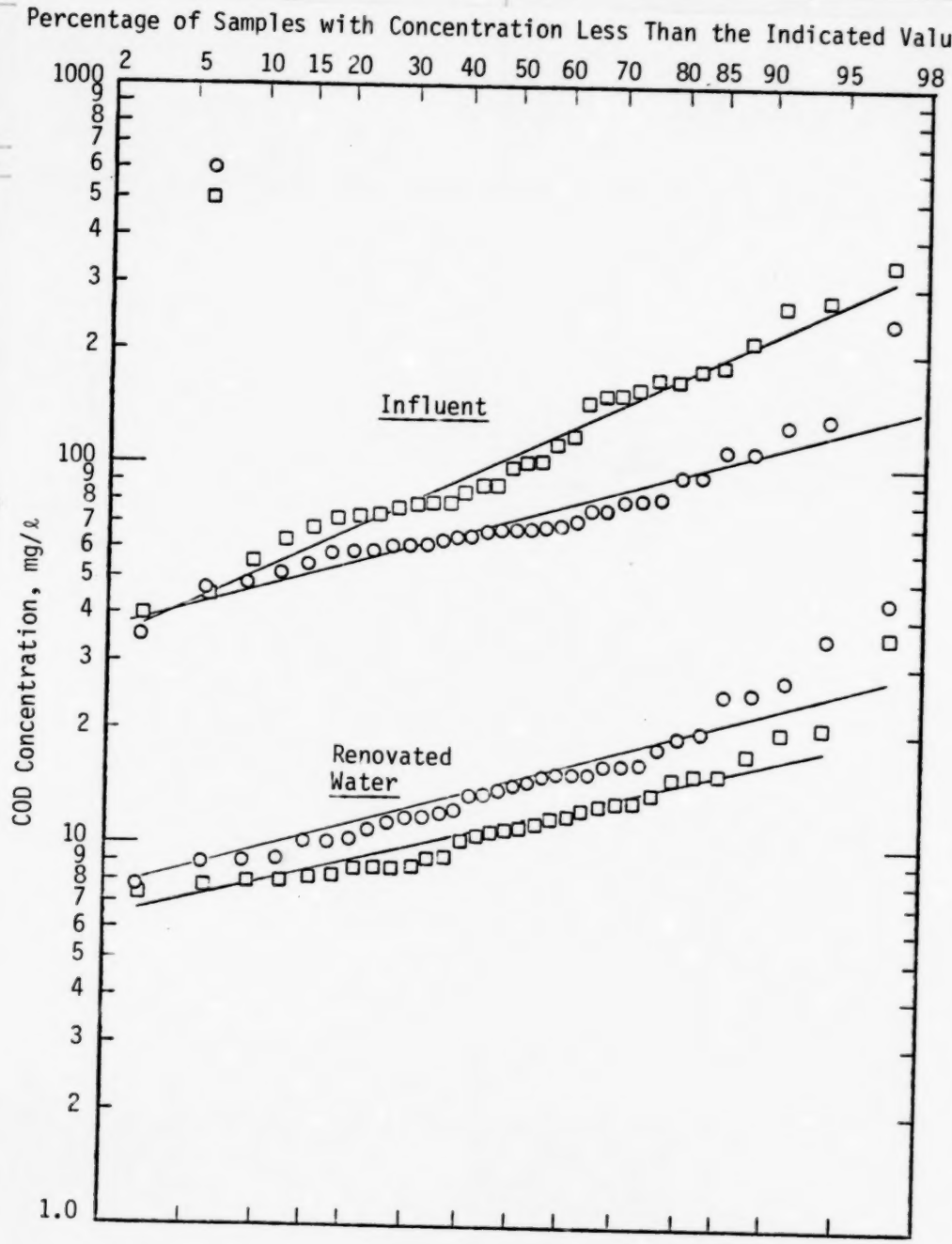
Percentage of Samples with Concentration Less Than the Indicated Value
2 5 10 15 20 30 40 50 60 70 80 85 90 95 98
1000 9 8 7 6 5 4 3 2
100 9 8 7 6 5 4 3 2
10 9 8 7 6 5 4 3 2
1.0
COD Concentration, mg/ℓ
Influent
Renovated Water

Figure 15. COD concentration variations (Basin 1).

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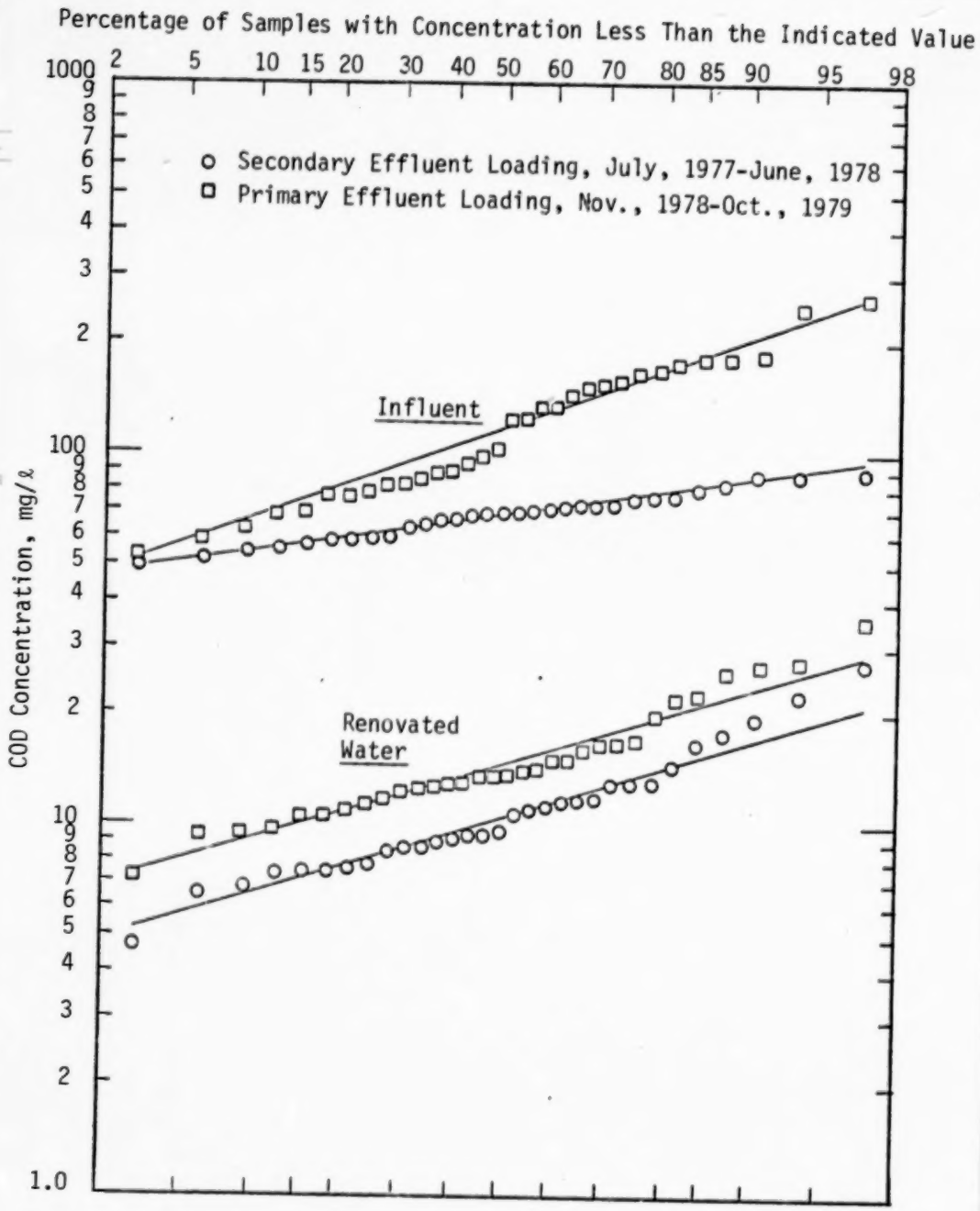
Percentage of Samples with Concentration Less Than the Indicated Value
2 5 10 15 20 30 40 50 60 70 80 85 90 95 98
1000
100
10
1.0
COD Concentration, mg/ℓ
Secondary Effluent Loading, July, 1977-June, 1978
Primary Effluent Loading, Nov., 1978-Oct., 1979
Influent
Renovated Water

Figure 16. COD concentration variations (Basin 2).

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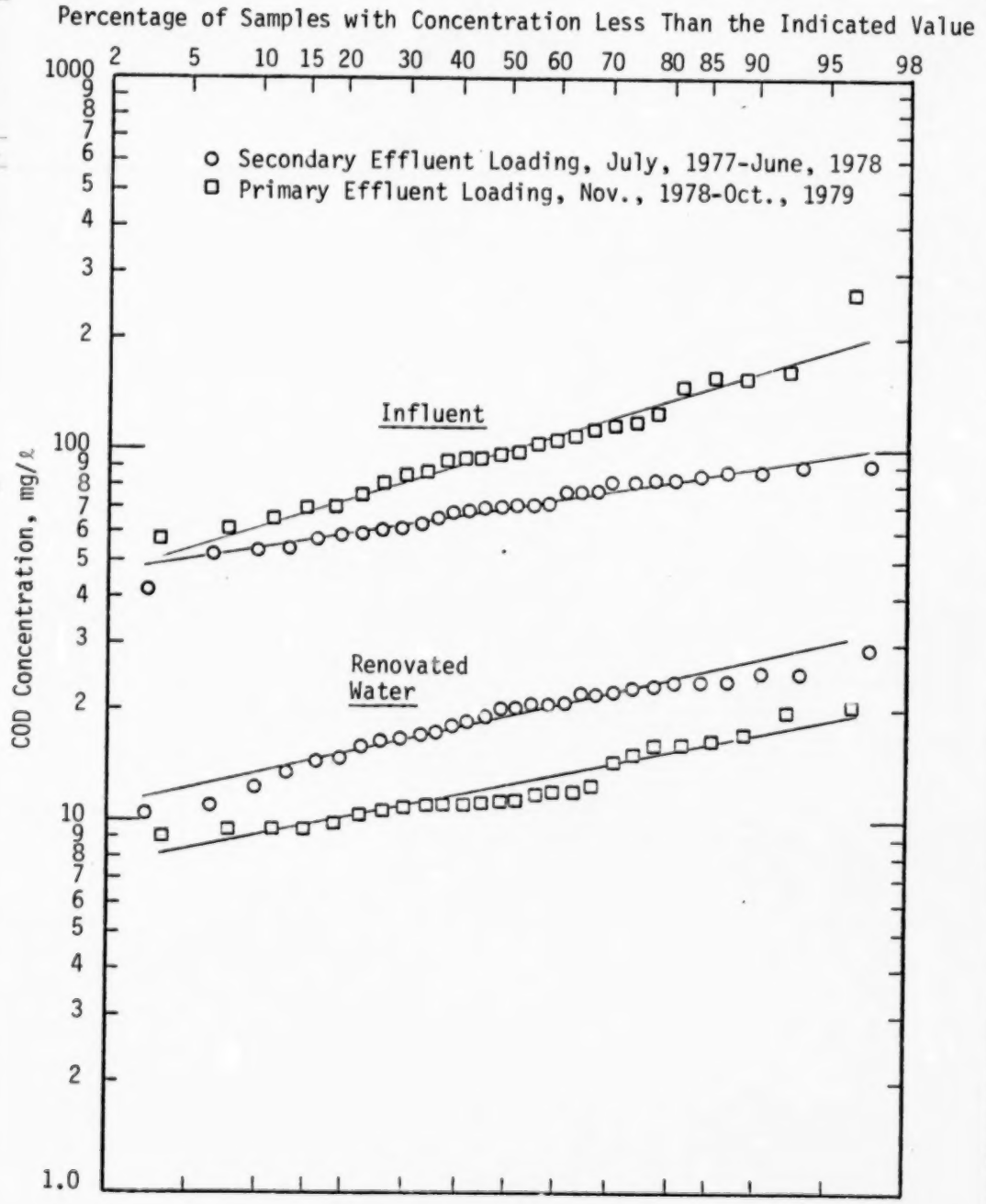
Percentage of Samples with Concentration Less Than the Indicated Value
2 5 10 15 20 30 40 50 60 70 80 85 90 95 98
1000 9 8 7 6 5 4 3 2
100 9 8 7 6 5 4 3 2
10 9 8 7 6 5 4 3 2
1.0
COD Concentration, mg/ℓ
Secondary Effluent Loading, July, 1977-June, 1978
Primary Effluent Loading, Nov., 1978-Oct., 1979
Influent
Renovated Water

Figure 17. COD concentration variations (Basin 3).

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PHOSPHORUS REDUCTION

Cycle average influent and renovated water total phosphorus concentrations have been presented in Figure 18. From these data it can be seen that phosphorus removals during the period of primary effluent application were generally between 60-90 percent. The general improvement in performance over that observed in the earlier study phase demonstrated the positive effects of low phosphorus loading rates and extended rest periods on renovated water phosphorus concentrations.

Based on data compiled during the first two years of the study, Smith et al. (10) noted several distinct trends: (1) some regeneration of phosphorus adsorption capacity occurred during rest periods, (2) the renovated water phosphorus concentration tended to increase with successive loadings within a cycle, and (3) the leakage levels were highest during the winter periods of high phosphorus loading and low wastewater temperatures. The results obtained during the year of primary effluent application were not inconsistent with these trends, and served to reinforce the experience during the first two years of operation. In addition to the previously noted trends, the sustained low levels of phosphorus leakage during the primary study indicated that it may be possible to obtain an equilibrium between phosphorus loading and the phosphorus removal mechanism.

The partial regeneration of phosphorus adsorption capacity was quite apparent during the start-up period in November, 1978. During the four month rest period prior to initiation of primary effluent loading, the base phosphorus concentrations (phosphorus concentrations during the first week of a cycle) had returned to a low level of about 0.30 mg/ℓ. This figure compares favorably with the 0.10 mg/ℓ base concentration achieved during the initial start-up of the basins in 1976. It is evident that the rest period between the secondary effluent phase and the primary effluent phase achieved a significant, although not complete, regeneration of the phosphorus adsorption capability. As in most types of adsorption systems, site regeneration is the controlling factor for long-term operation. In the case of phosphorus adsorption, site regeneration is dependent on slow mineralization/precipitation reactions. These reactions involve the development of iron and aluminum phosphate forms to expose a new site, or the precipitation of calcium phosphates. Lance noted that in calcareous soils a time-dependent precipitation of calcium phosphates controlled effluent concentrations after saturation of the soil adsorption capacity (11). This mechanism seems to be more dominant in neutral and high pH soils. Although the mineralization/precipitation processes have poor kinetics, they do appear to be capable of restoring nearly the entire adsorptive capacity of a rapid infiltration basin.

The renovated water phosphorus concentrations tended to increase within each loading cycle, as was the case in the previous years of study at the Boulder site. Figure 19 presents the weekly data for selected loading cycles which followed this trend. In most cases, the increases within a cycle were minor, with much of the lost adsorptive capacity recovered during the subsequent drying period.

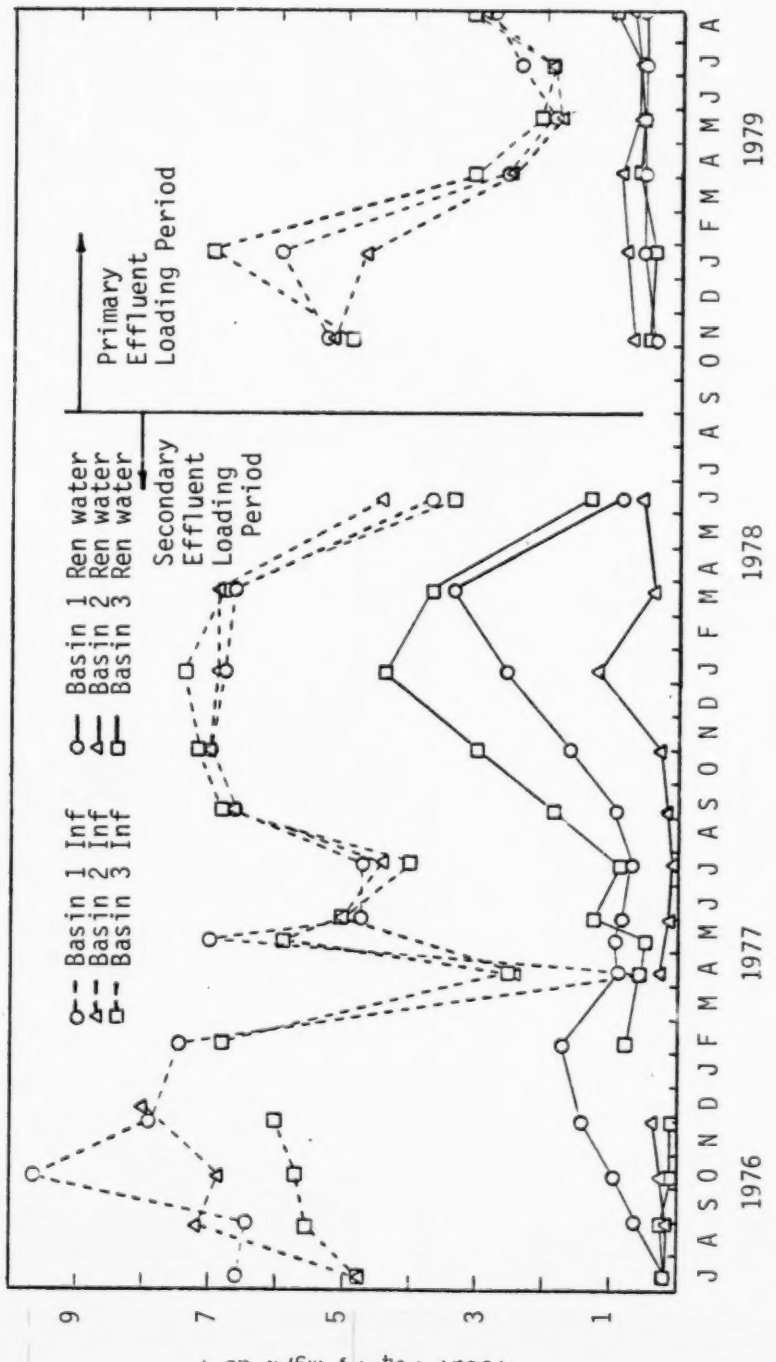

Figure 18. Influent and renovated water phosphorus concentrations.

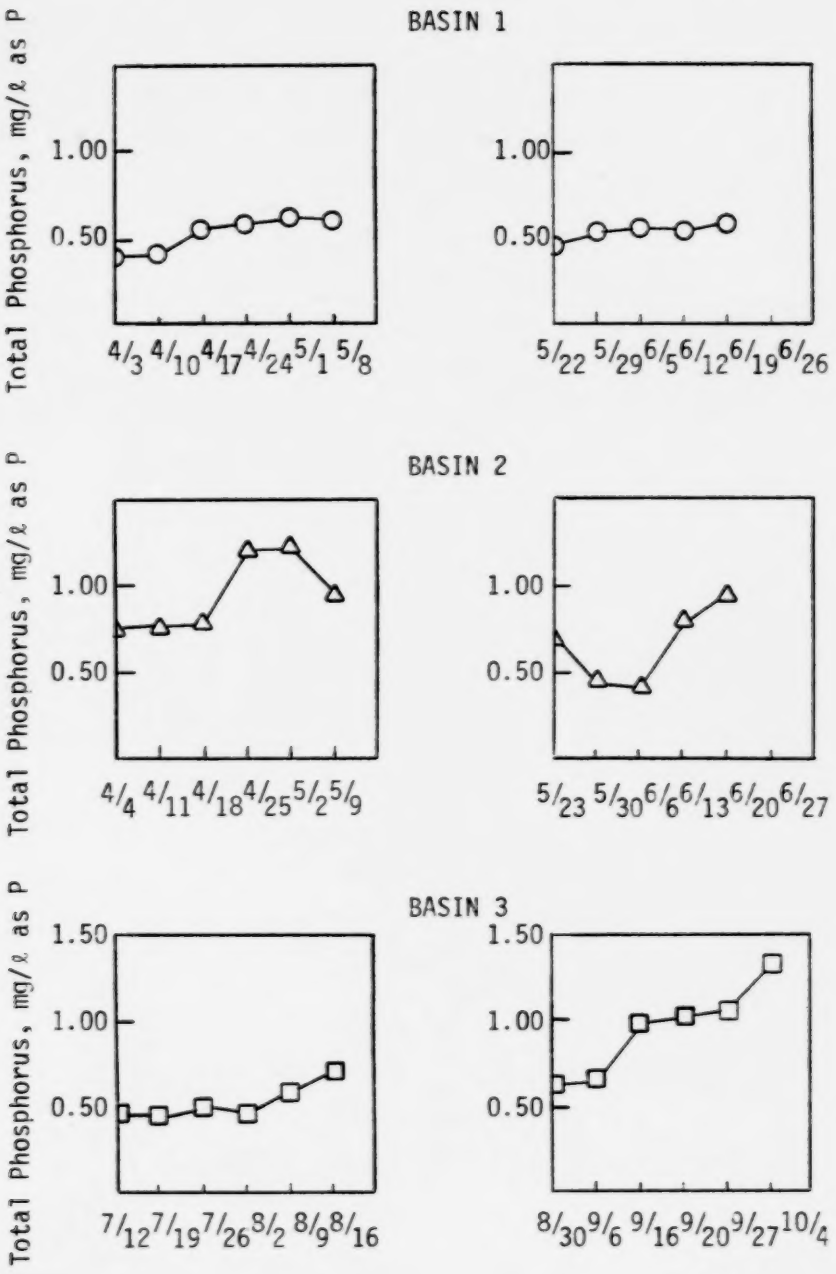

Figure 19. Total phosphates in renovated water - selected cycles.

A seasonal trend of increasing phosphorus leakage during the winter was not observed during the primary phase of study. It is likely that the leakage was not observed because the winter period of 1978-1979 coincided with the start-up of the primary effluent application period. As noted earlier, this start-up followed an extended rest period that seemed to restore much of the adsorptive capacity of the basins. The temperature effect on phosphorus removal seems to impact the flow mineralization process much more than the adsorption process. The effect of temperature on the slow mineralization of phosphorus has been reported by Barrow and Shaw (12).

The low levels of phosphorus discharge achieved throughout the primary effluent study phase demonstrate that an equilibrium between phosphorus loading and removal is achievable in a rapid infiltration system. The pattern of discharge during the primary effluent loading study seemed to be the result of a combination of long rest periods and relatively low phosphorus loading rates. The phosphorus concentration results from Basin 1 were particularly interesting in that this basin seemed to be operating near an equilibrium condition with respect to phosphorus loadings and mineralization. As previously noted, the renovated water phosphorus concentrations tended to increase with each loading within a cycle. Basin 1 was somewhat unique in that it was able to restore nearly all of its original capacity between cycles. The base concentration for Basin 1 increased from 0.31 mg/ℓ for the November 7, 1978 cycle to only 0.49 mg/ℓ for the August 28, 1979 cycle. The increases seen in Basins 2 and 3 were somewhat higher, probably due to the higher phosphorus loading rates in these basins.

COLIFORM BACTERIA

The fecal coliform density was measured twice per cycle during the last five cycles of the primary effluent loading study. The coliform removals throughout this period were consistently very good. Fecal coliform removals dropped below 99 percent in only four of the 30 evaluations. The average results of the primary effluent and secondary effluent study phases have been summarized for comparison in Table 6. As expected, coliform densities were somewhat higher in the applied primary effluent than in the secondary effluent applied earlier.

TABLE 6. FECAL COLIFORM REMOVAL DATA

		% Removal	Fecal coliform/100 ml
Secondary Effluent	Composite INF Ave		1×10^5
	Basin 1 RENOVATED WATER Ave	96.2	3800
	Basin 2 RENOVATED WATER Ave	99.1	900
	Basin 3 RENOVATED WATER Ave	99.0	1025
Primary Effluent	Composite INF Ave		6.2×10^5
	Basin 1 RENOVATED WATER Ave	99.8	618
	Basin 2 RENOVATED WATER Ave	97.5	4497
	Basin 3 RENOVATED WATER Ave	99.6	1791

The coliform concentrations in the renovated water showed some relationship to the loading rate. In the primary effluent study, the average renovated water concentrations could be ranked by the magnitude of their respective hydraulic/mass loading rates. Although this was not true in the secondary effluent study, there did seem to be a relationship between the renovated water densities obtained in each study and the hydraulic/mass loading rates employed during the periods of coliform analyses. Little information is available in the literature to explain the observed pattern.

The Basin 1 influent fecal coliform concentrations for both study phases and the renovated water coliform concentrations from the primary study were plotted on log-probability paper to graphically display the range of concentrations found in the respective samples (Figures 20 and 21). It can be noted from the data in Figure 21 that while the removal efficiency was good, the fecal coliform densities remaining in renovated water after 1.8 to 3.1 m (6 to 10 ft) of vertical travel were still high enough to preclude surface discharge to many streams in Colorado without disinfection.

DISSOLVED SALT CONSTITUENTS

The applied wastewater and renovated water were analyzed for hardness, calcium, alkalinity, and chlorides during the course of the study to trace the behavior of the major inorganic constituents in the rapid infiltration system. During the period of primary effluent application, the concentration data obtained from Basin 1 for these constituents differed markedly from those of Basins 2 and 3. This was consistent with the pattern during the secondary effluent portion of the study.

The average cycle data for renovated water hardness, and the change in hardness through the basins, have been presented in Figures 22 and 23. St. John noted an apparent movement toward an equilibrium condition for hardness in the basins in 1977 (13). The tendency toward establishment of an equilibrium condition in Basins 2 and 3 became apparent during the first half of 1978, and continued during the primary effluent loading study. By March, 1979 Basins 2 and 3 appeared to be close to an equilibrium condition, with no net difference in the hardness of the applied and renovated water. As would be expected, the calcium data in Figures 24 and 25 show the same trend. Basin 1, on the other hand, made no similar move toward equilibrium and continued to add approximately 30 to 50 mg/ℓ calcium to the applied water until the end of the project. An explanation for the behavior of the basins may be found in the mechanisms for removing the inorganic chemicals from applied wastewater.

Lindsay noted that the mechanisms resulting in removal of inorganic chemicals from soil solutions include ion exchange, precipitation, dissolution, and leaching (14). Ion exchange involves the exchange of a soluble cation for a solid phase cation on an exchange site. Precipitation may occur when the concentration of ions in the soil solution exceeds the solubility of solid phase compounds and minerals. Dissolution of mineral deposits within the soil will occur if the soil solution is undersaturated with respect to the solid phase. Leaching involves the removal of ions in the soil solution

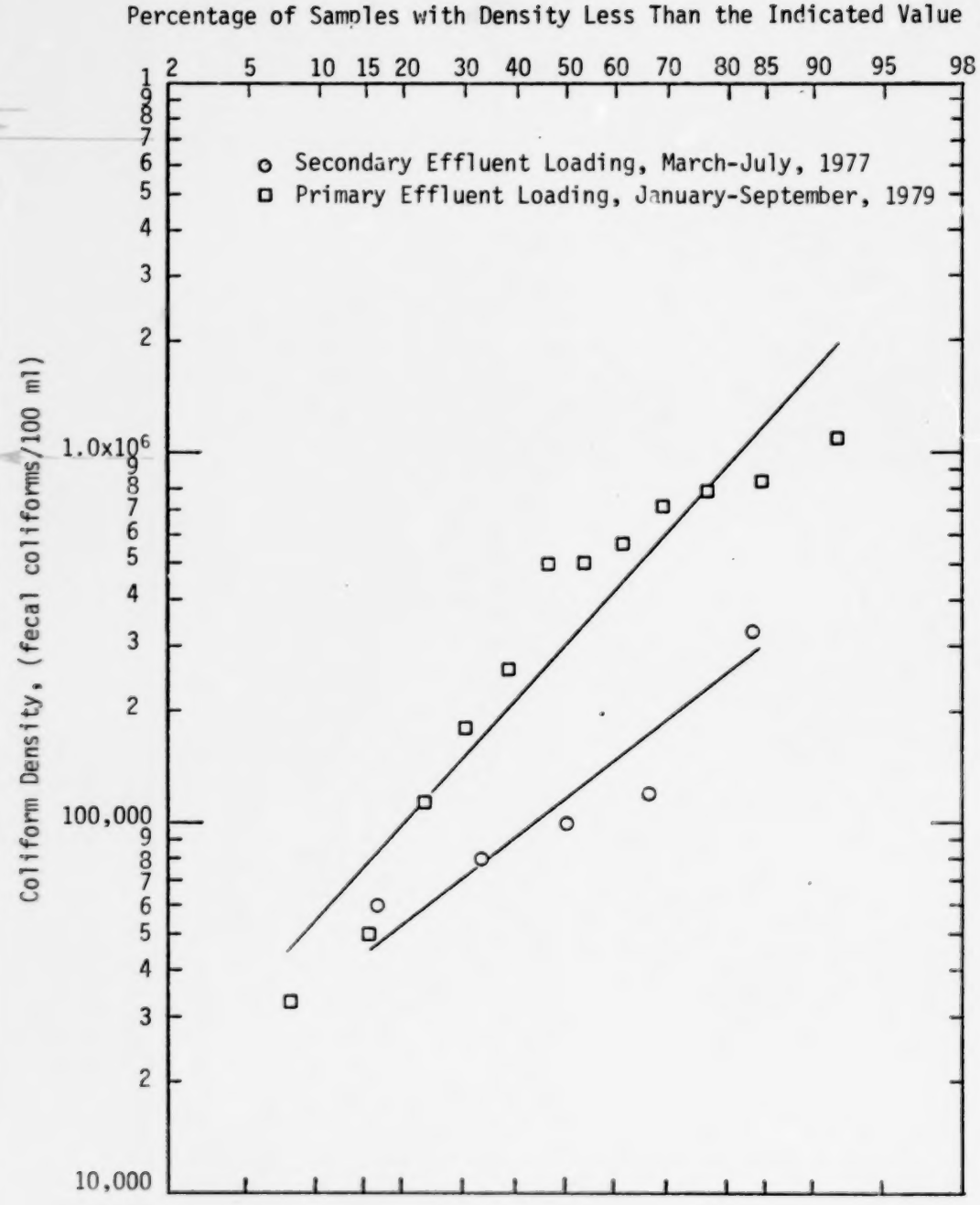
Percentage of Samples with Density Less Than the Indicated Value
2 5 10 15 20 30 40 50 60 70 80 85 90 95 98
Secondary Effluent Loading, March-July, 1977
Primary Effluent Loading, January-September, 1979
Coliform Density, (fecal coliforms/100 ml)
1.0x10^6
100,000
10,000

Figure 20. Variation in influent coliform density.

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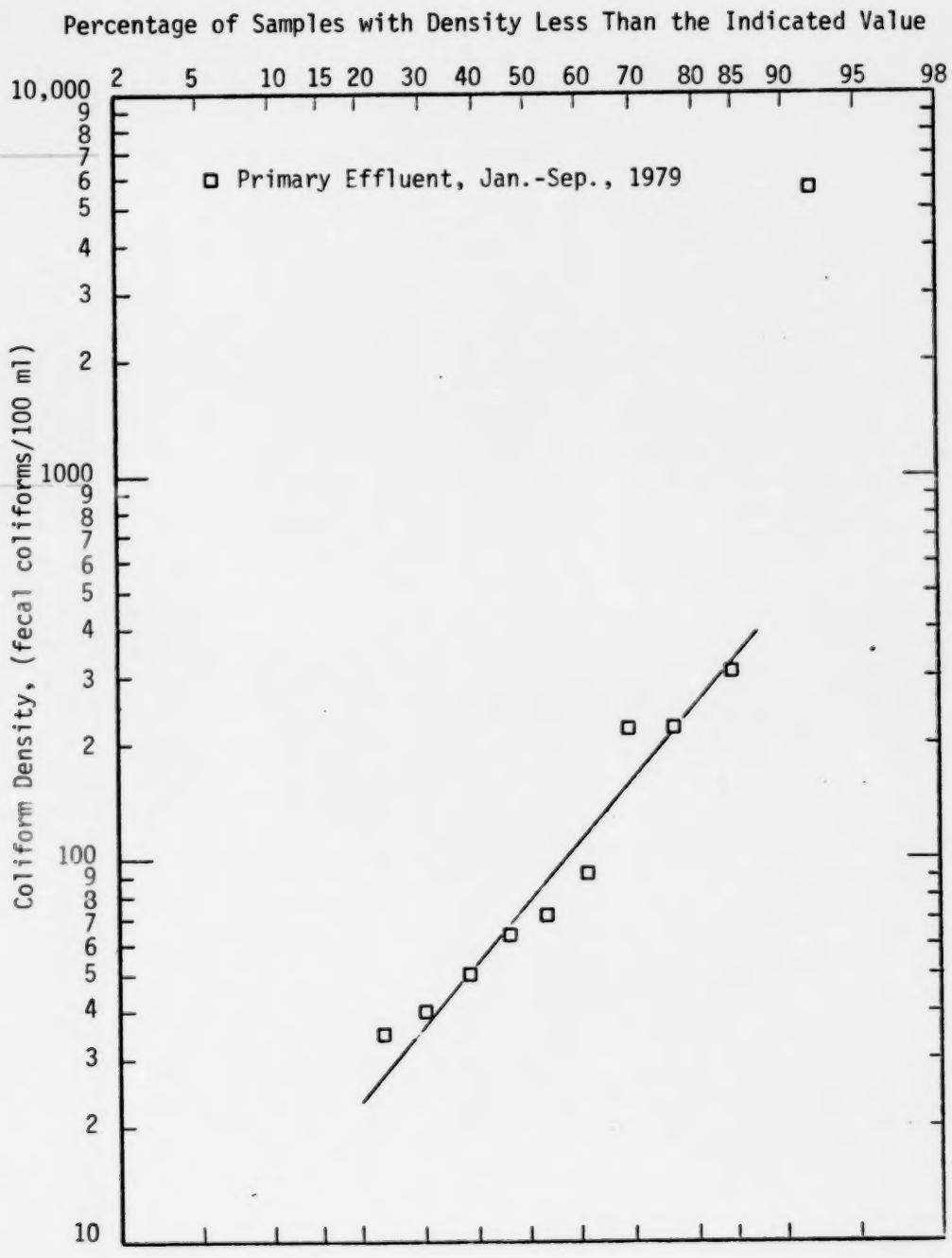
Percentage of Samples with Density Less Than the Indicated Value
2 5 10 15 20 30 40 50 60 70 80 85 90 95 98
Primary Effluent, Jan.-Sep., 1979
Coliform Density, (fecal coliforms/100 ml)
10,000
1000
100
10

Figure 21. Variation in renovated water coliform density.

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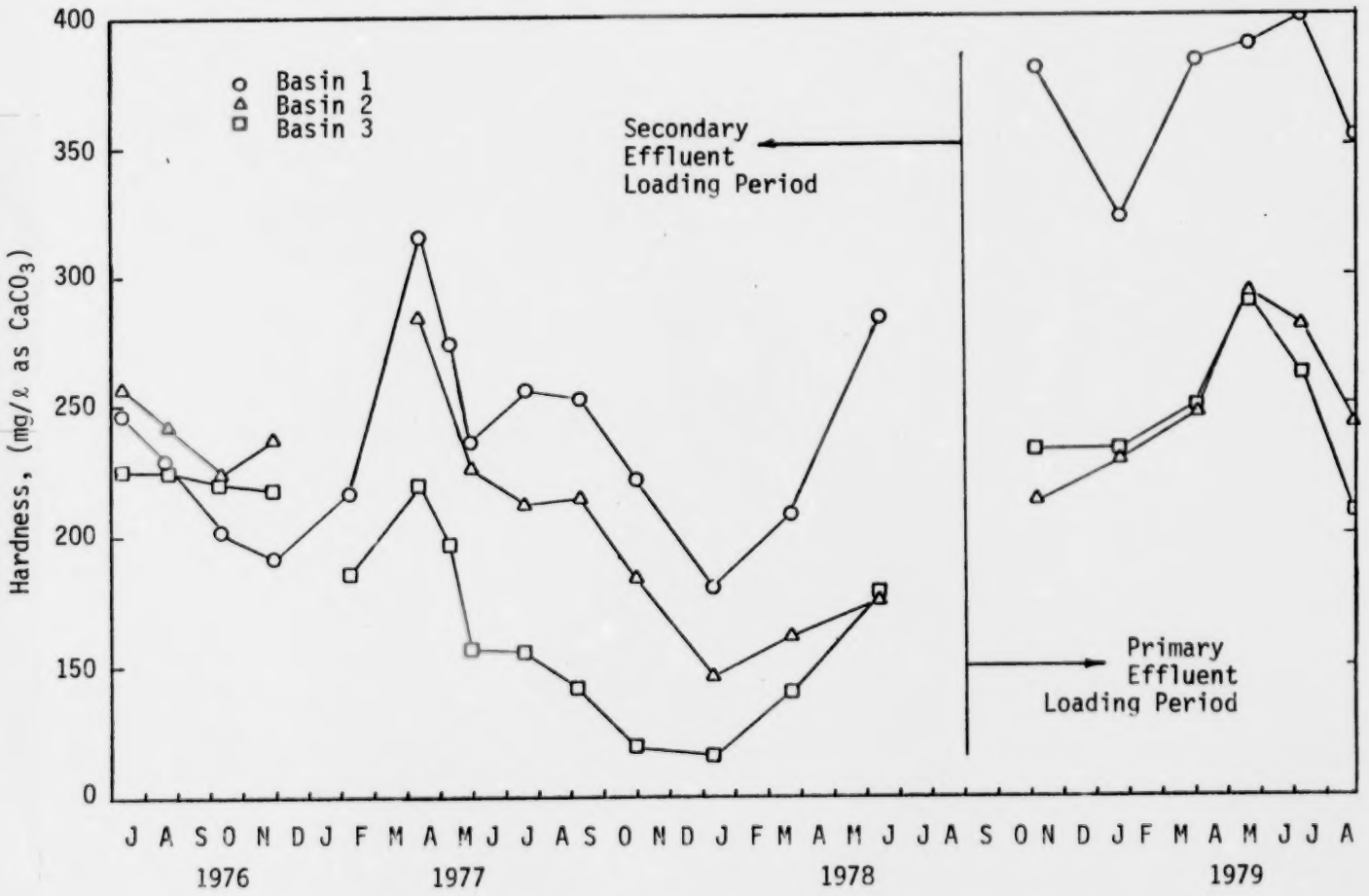

Figure 22. Renovated water hardness as a function of time.

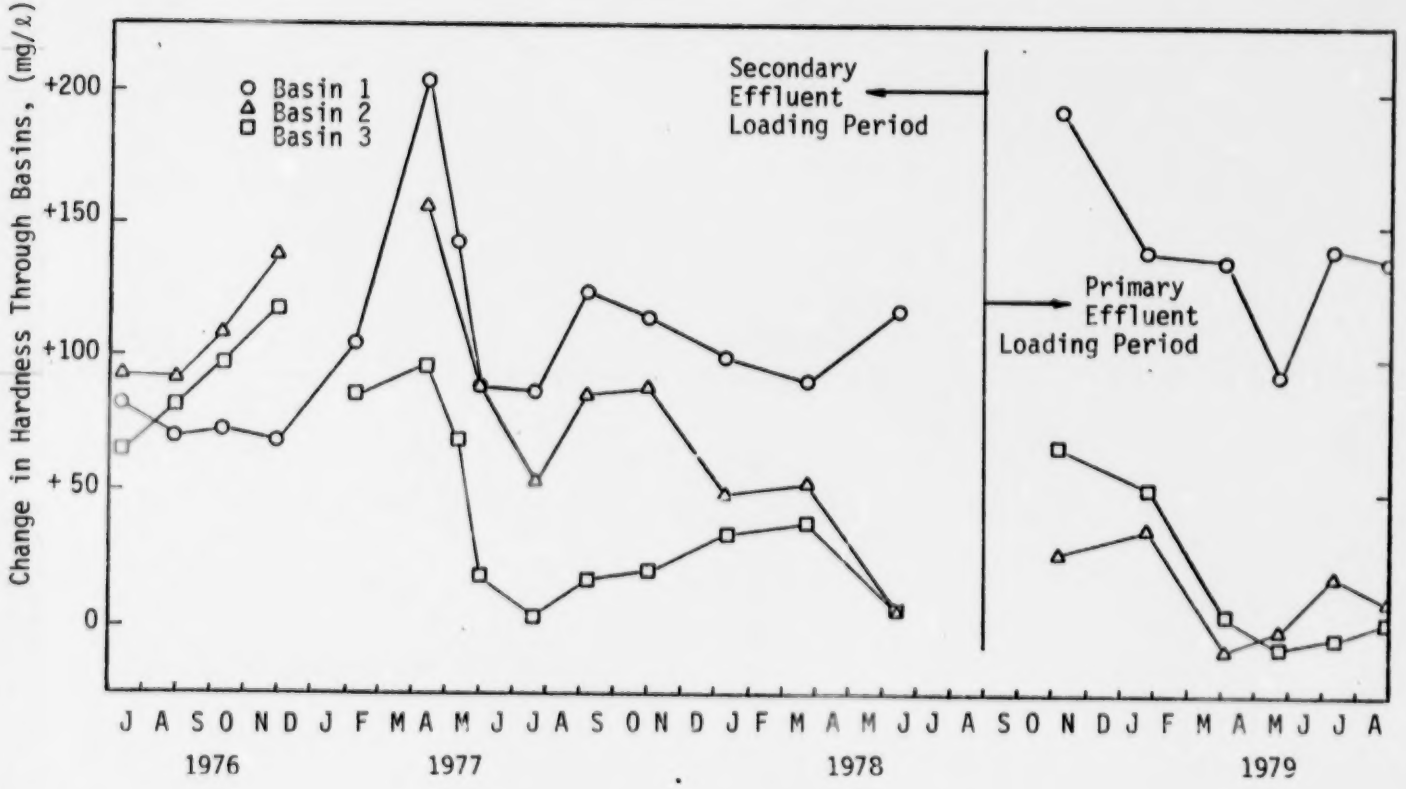

Figure 23. Change in hardness concentration through the basins.

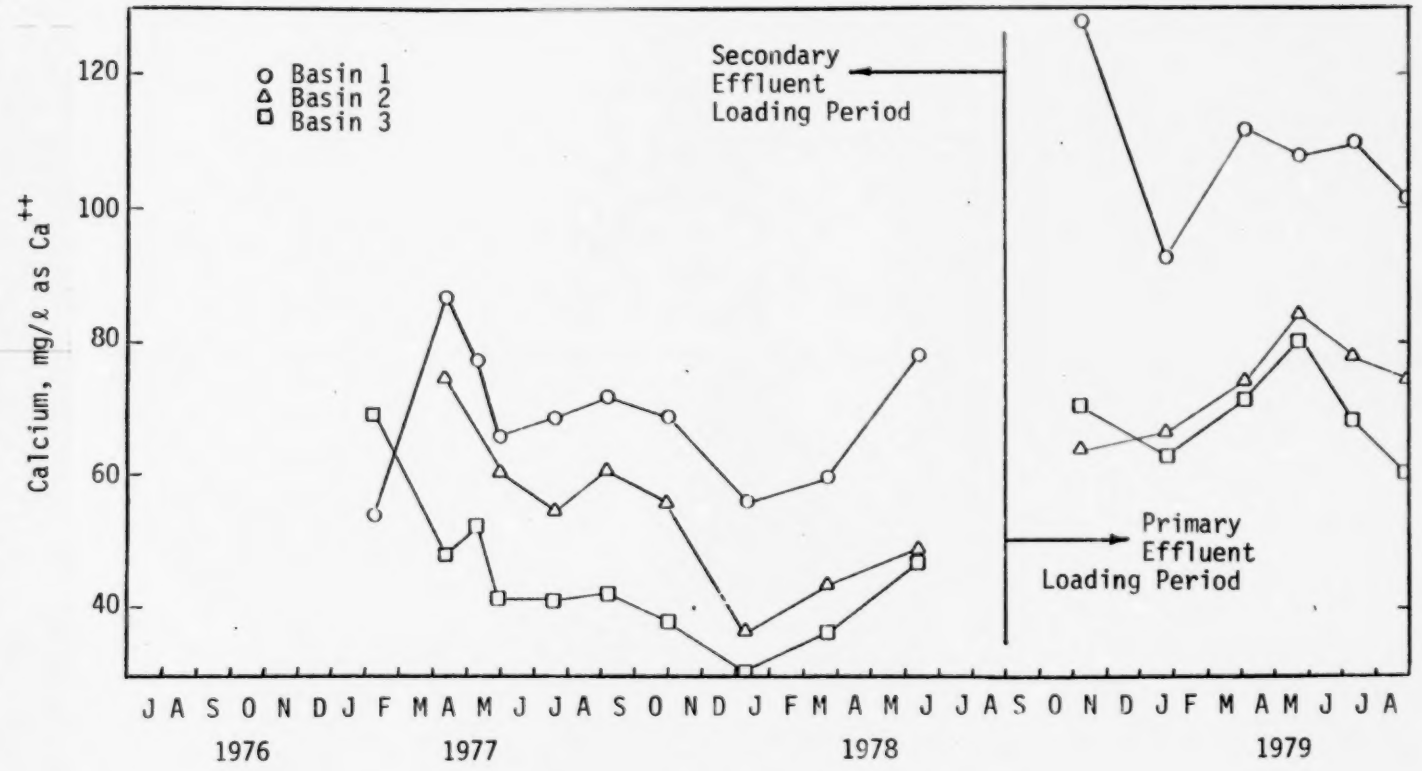

Figure 24. Renovated water calcium as a function of time.

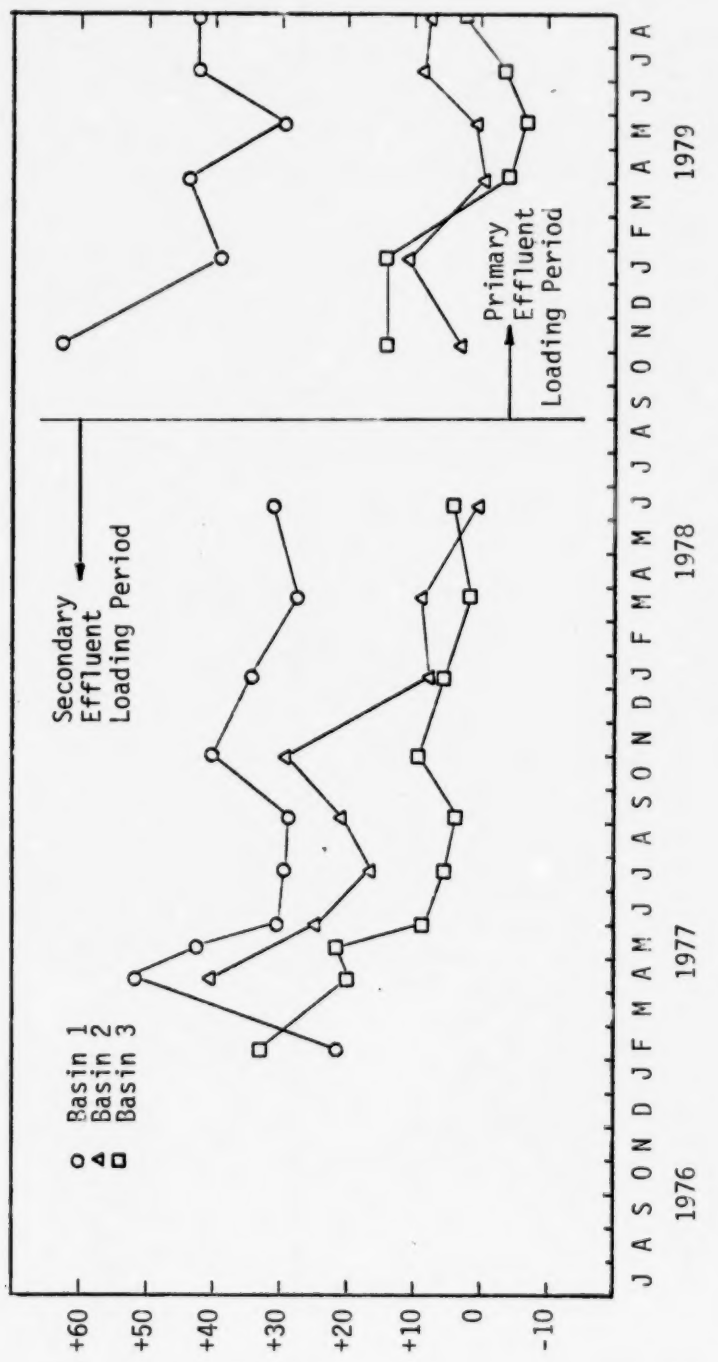

Figure 25. Change in calcium concentration through the basins.

by water moving through the soil profile. The significant increase in calcium in the Basin 1 leachate could be the result of dissolution and leaching of calcium-bearing minerals in the soil profile. In a rapid infiltration system, all of the indicated mechanisms may operate simultaneously during a loading cycle and produce a leachate quality which is substantially different from that of the applied wastewater. However, over a period of time it would be expected that these mechanisms would result in an equilibrium condition such as that observed in Basins 2 and 3.

Cycle averages for influent alkalinity, effluent alkalinity and the change in alkalinity through the basins have been presented in Figures 26 through 28. Once again, Basin 1 was unique in that it maintained the highest renovated water alkalinity during the primary effluent study, while the other basins showed a decline in alkalinity.

The influent alkalinity was plotted to highlight any changes that may have occurred as a result of the change in the quality of the applied water. The influent alkalinity was somewhat higher during the period of primary effluent application. However, despite the increase in alkalinity in the applied wastewater, renovated water from Basins 2 and 3 continued to show alkalinity concentrations comparable to those of the previous years. Wastewater applied to Basin 1 showed no decrease in alkalinity after percolating through the soil. In fact, an increase was noted during the final two cycles of the study.

AESTHETIC CONSIDERATIONS

Aesthetic considerations are significant in the overall evaluations of any wastewater treatment system. As such, the physical appearance and the development of any possible nuisance conditions were monitored during the course of the primary effluent application study.

While there was some concern prior to initiation of the study, odor control was not a problem during the period of primary effluent application. No complaints were received concerning odors from the beds, and in fact, the only odor associated with the beds themselves was the unobjectional earthy smell of the applied wastewater. At the influent end of the basins, a faint odor was apparent near the distribution box during the first few minutes of each loading. This was apparently due to a depression in the pipeline from the primary clarifier where anaerobic conditions allowed the formation of hydrogen sulfide gas.

At the west end of Basin 1, near the wastewater inlet, large accumulations of solids resulted in minor ponding over a small area. This solids distribution problem would most likely be alleviated by a system that provided a more uniform distribution of flow.

Despite scarification of the surface of Basins 1 and 3 between each cycle, a substantial growth of weeds and naturally occurring grasses covered the basins during the spring and summer months. In fact, the growth was so heavy that it made scarification a very difficult task.

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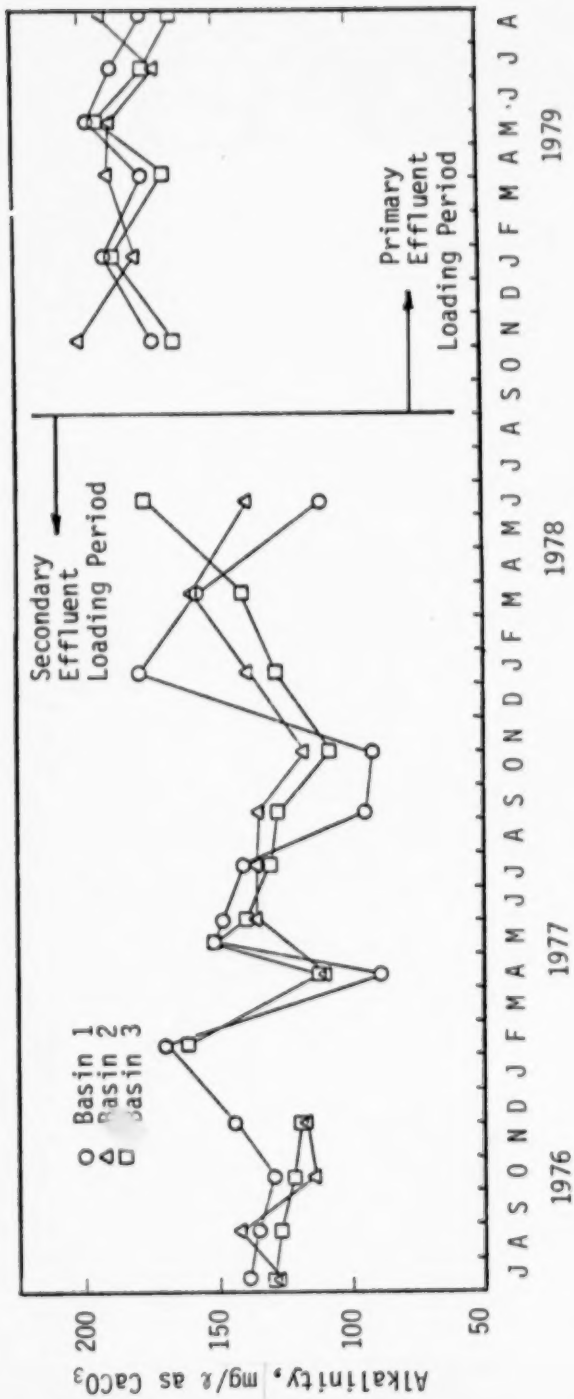

Figure 26. Influent alkalinity as a function of time.

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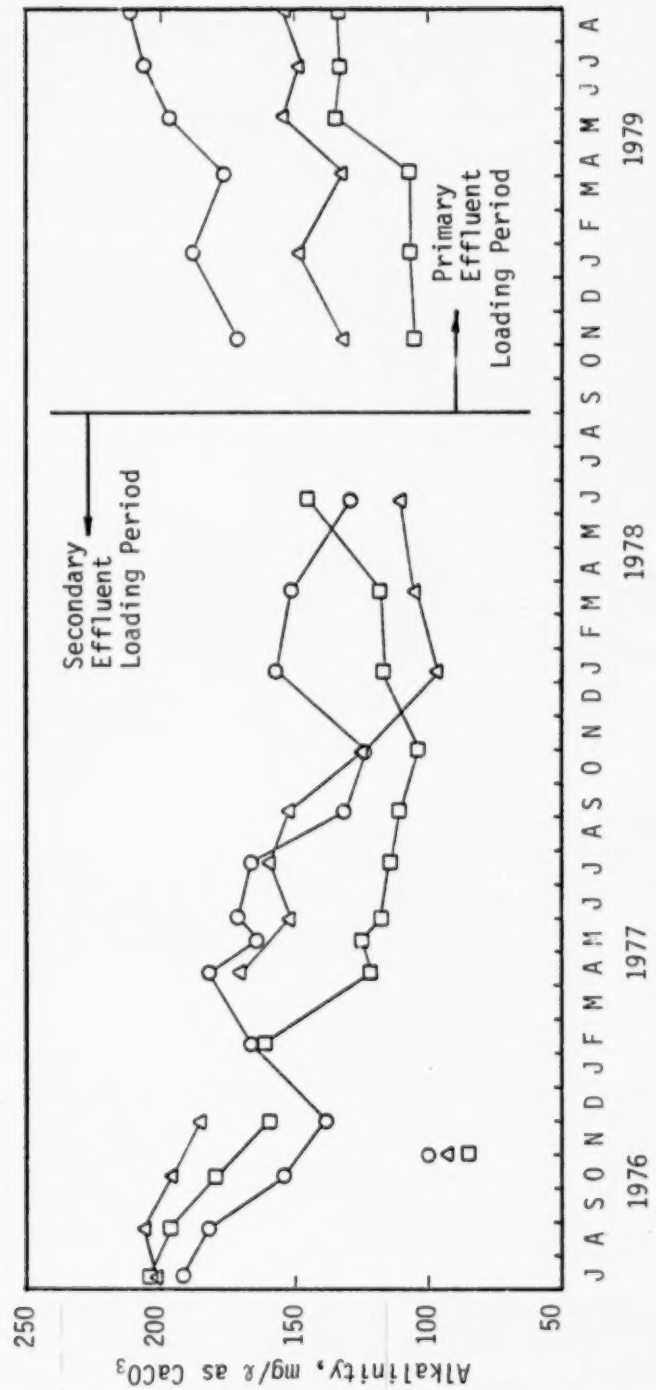

Figure 27. Renovated water alkalinity as a function of time.

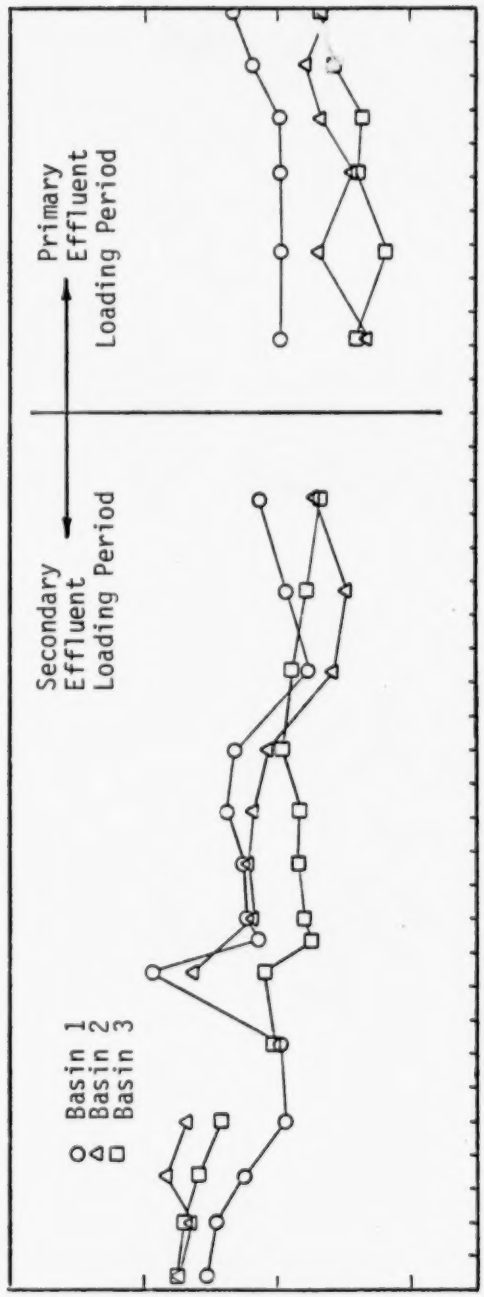

Figure 28. Change in alkalinity concentration through the basins.

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The entire basin area was very biologically active during the spring and summer months, with large numbers of insects and birds living in and around the basins. This activity was typical of the surrounding low lands, and seemed little impaired by the application of the primary effluent.

SECTION 6

ECONOMIC COMPARISON OF WASTEWATER TREATMENT ALTERNATIVES

The Federal Water Pollution Control Act as amended in 1972 required that publically owned treatment works (POTW) utilize the BPWTT by July 1, 1983 (15). The Clean Water Act of 1977 and accompanying changes in the grants regulations specified that municipalities must evaluate alternative and innovative processes in their efforts to comply. Additionally, an increasing percentage of the construction funds allotted to each state must be spent on such processes (16). At a minimum, conventional, land treatment, and reuse alternatives must be evaluated for their cost-effectiveness.

With the promising treatment results which were developed in this study, it was considered appropriate to assess the economic feasibility of the rapid infiltration technology which was evaluated. This has been done by comparing several different treatment approaches for achieving a BPWTT. The economic evaluation utilized EPA cost data found in EPA report EPA 430/9-75-022, the revised edition of EPA 430/9-75-003 and EPA 430/9-77-013 (17,18,19) to make a preliminary cost comparison of a few alternatives available to a community attempting to upgrade their treatment capability to the BPWTT. The alternatives are listed below:

Existing Treatment	Alternative	Treatment Required
None	1	A-B-D-F-H-I
None	2	A-B-C-E-F-H-I
Primary	3	D-F
Primary	4	C-E-F
Secondary	5	F
Secondary	6	E-F
None	7	A-G-J
None	8	A-G-J-K-H
None	9	A-J-K-H
None	10	A-J
Primary	11	G
Primary	12	G-J-K
Primary	13	J-K
Primary	14	J
Secondary	15	J-K
Secondary	16	J

PROCESS DESCRIPTIONS/TREATMENT COSTS

A - Preliminary treatment; includes flow metering, screening grit removal and influent pumping

B - Primary sedimentation

C - High-rate activated sludge; includes secondary clarifiers

D - Conventional activated sludge; includes secondary clarifiers

E - Biological nitrification; includes final clarifiers

F - Filtration

G - Partial mix aerated lagoon

H - Disinfection

I - Sludge handling; includes anaerobic digestion and mechanical dewatering

J - Rapid infiltration; transmission; storage (1 wk)

K - Surface discharge; includes recovery wells

Laboratory and maintenance facilities costs.

Construction component costs; include sitework mobilization, excavation, electrical, controls, instrumentation, yard piping and HVAC. These costs included in land treatment costs.

Additional costs; include costs associated with monitor wells, fencing and service roads.

Non-construction costs; include contingency, engineering, interest during construction, administration, etc. estimated at 35 percent of the construction cost.

Land costs; present worth of total land requirement corrected for salvage value at the end of 20 yrs.

ASSUMPTIONS

1. Average daily flow, 0.04 m^3/sec [1 million gallons/day (MGD)]; peaking factor = 3.

2. Processes G, J, and K adjusted to June 1979 with a Sewer Construction Cost index of 358.3.

3. All other processes adjusted to June 1979 with a Sewage Treatment Plant cost index of 334.1.

4. Construction component costs adjusted to June 1979 with a Small City Conventional Treatment Plant index of 152.5.

5. Transmission from plant to land treatment site accomplished by 0.81 kilometers (km) [0.5 miles (mi)] of gravity pipe with 2.74 m (9 ft) of cover. Transmission system includes a pump station with 15.2 m (50 ft) of total head.

6. Discharge from recovery wells to surface water accomplished by 1.62 km (1 mi) of force main.

7. Application rate 29.2 cm/wk (11.5 in/wk) with 13 weeks of idle time scheduled for each basin.

8. Land cost estimated at $2025/ha ($5000/ac) was appreciated 3 percent annually.

9. Total land requirement for the land treatment option [126 ha (51 ac)] included a field area of 89 ha (36 ac), a 100 ft buffer zone [32 ha (13 ac)], a storage area [4.9 ha (2 ac)], and a lagoon area.

10. All existing plants assumed to have disinfection and sludge handling capability.

Although this evaluation examined only a limited number of alternatives it did become apparent that in situations requiring a nitrified effluent with low BOD and SS, the rapid infiltration system is quite competitive at the 1 MGD level. For purposes of comparison the rapid infiltration system was assumed to have an effluent quality approximately equal to that of a secondary plant with nitrification and filtration.

Tables 7-9 indicate that even with a very conservative design (such as that used in the evaluation) a rapid infiltration system may offer high quality treatment at less than half the cost of comparable in-plant processes. With such obvious benefits at the 0.04 m^3/sec (1 MGD) level of operation an additional evaluation was accomplished to determine the effect of large scale operations on the treatment costs of alternatives 2 and 8. These two alternatives were evaluated at the 0.4, 2.0, and 4.0 m^3/sec (10, 50 and 100 MGD) levels. The process descriptions and assumptions remain the same except for the following:

The 0.4 m /sec (10 MGD) system will include:

a. a transmission pump station with 45.6 m (150 ft) total head
b. 1520 m (5000 ft) of force main in the transmission system
c. 1520 m (5000 ft) of gravity pipe in the transmission system
d. recovery wells with 15.2 m (50 ft) total head
e. 1520 m (5000 ft) force main for discharge
f. field area 897 ha (363 ac); total area 1067 ha (432 ac)

TABLE 7. CAPITAL COSTS OF TREATMENT ALTERNATIVES
cents/m³ (cents/1000 gal)[a]

Alternative	Preliminary Treatment	Primary Sedimentation	Activated Sludge	Biological Nitrification	Filtration	Disinfection	Sludge Handling	Mx & Lab Facilities	Const. Component Costs	Non-Const. Costs	Land Cost	Total Capital
1	2.5 (9.5)	2.0 (7.6)	5.7 (21.6)		3.0 (11.2)	0.8 (3.2)	3.8 (14.4)	1.4 (5.3)	4.5 (16.9)	8.2 (31.4)	0.1 (0.2)	32.0 (121.3)
2	2.5 (9.5)	2.0 (7.6)	5.2 (19.6)	3.5 (13.1)	3.0 (11.2)	0.8 (3.2)	3.8 (14.1)	1.4 (5.3)	5.2 (19.7)	9.6 (36.3)	0.1 (0.2)	37.1 (140.1)
3			5.7 (21.6)		3.0 (11.2)				2.2 (8.2)	3.8 (14.4)	0.0 (0.0)	14.7 (55.4)
4			5.2 (19.6)	3.5 (13.1)	3.0 (11.2)				2.9 (11.0)	5.1 (19.2)	0.0 (0.0)	19.7 (74.1)
5					3.0 (11.2)				0.7 (2.8)	1.3 (4.9)	0.0 (0.0)	5.0 (18.9)
6				3.5 (13.1)	3.0 (11.2)				1.6 (6.1)	2.8 (10.6)		10.9 (41.0)
	Preliminary Treatment	Aerated Lagoon	Transmission & Pumping	Storage	Rapid Infiltration	Surface Discharge	Disinfection	Mx & Lab Facilities	Additional Costs	Non-Const. Costs	Land Cost	Total Capital
7	2.5 (9.5)	0.7 (2.7)	2.3 (8.8)	0.8 (2.9)	1.6 (6.0)			0.6 (2.4)	0.5 (1.8)	3.1 (11.9)	0.9 (3.5)	13.0 (49.5)
8	2.5 (9.5)	0.7 (2.7)	2.3 (8.8)	0.8 (2.9)	1.6 (6.0)	1.1 (4.1)	0.4 (1.7)	0.6 (2.4)	0.5 (1.8)	3.7 (14.0)	0.9 (3.5)	15.1 (49.4)
9	2.5 (9.5)		2.3 (8.8)	0.8 (2.9)	1.6 (6.0)	1.1 (4.1)	0.4 (1.7)	0.6 (2.4)	0.5 (1.8)	3.4 (13.0)	0.9 (3.5)	14.1 (53.7)
10	2.5 (9.5)		2.3 (8.8)	0.8 (2.9)	1.6 (6.0)			0.6 (2.4)	0.5 (1.8)	2.9 (11.0)	0.9 (3.5)	12.1 (45.9)
11		0.7 (2.7)								0.2 (0.9)	0.1 (0.2)	1.0 (3.8)
12		0.7 (2.7)	2.3 (8.8)	0.8 (2.9)	1.6 (6.0)	1.1 (4.1)			0.5 (1.8)	2.4 (9.2)	0.9 (3.5)	10.3 (39.0)
13			2.3 (8.8)	0.8 (2.9)	1.6 (6.0)	1.1 (4.1)			0.5 (1.8)	2.2 (8.3)	0.9 (3.5)	9.4 (35.4)
14			2.3 (8.8)	0.8 (2.9)	1.6 (6.0)				0.5 (1.8)	1.8 (6.8)	0.9 (3.5)	7.9 (29.8)
15			2.3 (8.8)	0.8 (2.9)	1.6 (6.0)	1.1 (4.1)			0.5 (1.8)	2.2 (8.3)	0.9 (3.5)	9.4 (35.4)
16			2.3 (8.8)	0.8 (2.9)	1.6 (6.0)				0.5 (1.8)	1.8 (6.8)	0.9 (3.5)	7.9 (29.8)

[a]All costs adjusted to June 1979; capital costs amortized over 20 years @ 7%.

TABLE 8. OPERATION AND MAINTENANCE COSTS
cents/m^3 (cents/1000 gal)[a]

Alternative	Preliminary Treatment	Primary Sedimentation	Activated Sludge	Biological Nitrification	Filtration	Disinfection	Sludge Handling	Mx & Lab Facilities	Total O & M
1	1.9 (7.1)	1.5 (5.6)	4.7 (17.9)		2.8 (10.6)	0.5 (1.8)	3.5 (12.9)	2.0 (7.5)	16.8 (63.4)
2	1.9 (7.1)	1.5 (5.6)	4.5 (17.0)	3.9 (14.6)	2.8 (10.6)	0.5 (1.8)	3.4 (12.9)	2.0 (7.5)	20.5 (77.1)
3			4.7 (17.9)		2.8 (10.6)				7.5 (28.5)
4			4.5 (17.0)	3.9 (14.6)	2.8 (10.6)				11.2 (42.2)
5					2.8 (10.6)				2.8 (10.6)
6				3.9 (14.6)	2.8 (10.6)				6.7 (25.2)

	Preliminary Treatment	Aerated Lagoon	Transmission & Pumping	Storage	Rapid Infiltration	Surface Discharge	Disinfection	Mx & Lab Facilities	Additional O & M	Total O & M
7	1.9 (7.1)	1.2 (4.6)	0.7 (2.5)	0.0 (0.0)	1.6 (6.0)			1.0 (3.9)	0.2 (0.6)	6.6 (24.7)
8	1.9 (7.1)	1.2 (4.6)	0.7 (2.5)	0.0 (0.0)	1.6 (6.0)	0.6 (2.1)	0.5 (1.8)	1.0 (3.9)	0.2 (0.6)	7.7 (28.6)
9	1.9 (7.1)		0.7 (2.5)	0.0 (0.0)	1.6 (6.0)	0.6 (2.1)	0.5 (1.8)	1.0 (3.9)	0.2 (0.6)	6.5 (24.0)
10	1.9 (7.1)		0.7 (2.5)	0.0 (0.0)	1.6 (6.0)			1.0 (3.9)	0.2 (0.6)	5.4 (20.1)
11		1.2 (4.6)								1.2 (4.6)
12		1.2 (4.6)	0.7 (2.5)	0.0 (0.0)	1.6 (6.0)	0.6 (2.1)			0.2 (0.6)	4.3 (15.8)
13			0.7 (2.5)	0.0 (0.0)	1.6 (6.0)	0.6 (2.1)			0.2 (0.6)	3.1 (11.2)
14			0.7 (2.5)	0.0 (0.0)	1.6 (6.0)				0.2 (0.6)	2.5 (9.1)
15			0.7 (2.5)	0.0 (0.0)	1.6 (6.0)	0.6 (2.1)			0.2 (0.6)	3.1 (11.2)
16			0.7 (2.5)	0.0 (0.0)	1.6 (6.0)				0.2 (0.6)	2.5 (9.1)

[a]All costs adjusted to June 1979.

TABLE 9. TOTAL COSTS OF TREATMENT ALTERNATIVES
cents/m^3 (cents/1000 gal)[a]

Alternative	Preliminary Treatment	Primary Sedimentation	Activated Sludge	Biological Nitrification	Filtration	Disinfection	Sludge Handling	Mx & Lab Facilities	Const. Component Costs	Non-Const. Costs	Land Cost	Total Capital
1	4.4 (16.6)	3.5 (13.2)	10.4 (39.5)		5.8 (21.8)	1.3 (5.0)	7.2 (27.3)	3.4 (12.8)	4.5 (16.9)	8.3 (31.4)	0.1 (0.2)	48.8 (184.7)
2	4.4 (16.6)	3.5 (13.2)	9.7 (36.6)	7.3 (27.7)	5.8 (21.8)	1.3 (5.0)	7.2 (27.3)	3.4 (12.8)	5.2 (19.7)	9.6 (36.3)	0.1 (0.2)	57.3 (217.2)
3			10.4 (39.5)		5.8 (21.8)				2.2 (8.2)	3.8 (14.4)	0.0 (0.0)	22.1 (83.9)
4			9.7 (36.6)	7.3 (27.7)	5.8 (21.8)				2.9 (11.0)	5.1 (19.2)	0.0 (0.0)	31.0 (116.3)
5					5.8 (21.8)				0.7 (2.8)	1.3 (4.9)	0.0 (0.0)	7.8 (29.5)
6				7.3 (27.7)	5.8 (21.8)				1.6 (6.1)	2.8 (10.6)	0.0 (0.0)	17.4 (66.2)
	Preliminary Treatment	Aerated Lagoon	Transmission & Pumping	Storage	Rapid Infiltration	Surface Discharge	Disinfection	Mx & Lab Facilities	Additional Costs	Non-Const. Costs	Land Cost	Total Capital
7	4.4 (16.6)	1.9 (7.3)	3.0 (11.3)	0.8 (2.9)	3.2 (12.0)			1.7 (6.3)	0.6 (2.4)	3.1 (11.9)	0.9 (3.5)	19.8 (74.2)
8	4.4 (16.6)	1.9 (7.3)	3.0 (11.3)	0.8 (2.9)	3.2 (12.0)	1.6 (6.2)	0.9 (3.5)	1.7 (6.3)	0.6 (2.4)	3.7 (14.0)	0.9 (3.5)	22.8 (86.0)
9	4.4 (16.6)		3.0 (11.3)	0.8 (2.9)	3.2 (12.0)	1.6 (6.2)	0.9 (3.5)	1.7 (6.3)	0.6 (2.4)	3.4 (13.0)	0.9 (3.5)	20.8 (77.7)
10	4.4 (16.6)		3.0 (11.3)	0.8 (2.9)	3.2 (12.0)			1.7 (6.3)	0.6 (2.4)	3.0 (11.0)	0.9 (3.5)	17.8 (66.0)
11		1.9 (7.3)								0.2 (0.9)	0.1 (0.2)	2.2 (8.4)
12		1.9 (7.3)	3.0 (11.3)	0.8 (2.9)	3.2 (12.0)	1.6 (6.2)			0.6 (2.4)	2.4 (9.2)	0.9 (3.5)	14.4 (54.8)
13			3.0 (11.3)	0.8 (2.9)	3.2 (12.0)	1.6 (6.2)			0.6 (2.4)	2.2 (8.3)	0.9 (3.5)	12.3 (46.6)
14			3.0 (11.3)	0.8 (2.9)	3.2 (12.0)				0.6 (2.4)	1.8 (6.8)	0.9 (3.5)	10.3 (38.9)
15			3.0 (11.3)	0.8 (2.9)	3.2 (12.0)	1.6 (6.2)			0.6 (2.4)	2.2 (8.3)	0.9 (3.5)	12.3 (46.6)
16			3.0 (11.3)	0.8 (2.9)	3.2 (12.0)				0.6 (2.4)	1.8 (6.8)	0.9 (3.5)	10.3 (38.9)

[a]All costs adjusted to June 1979.

The 2.0 m^3/sec (50 MGD) system will include:

a. a transmission pump station with 91.2 m (300 ft) total head
b. 15,200 (50,000 ft) of gravity transmission pipe
c. 1520 m (5000 ft) of force main in transmission system
d. recovery wells with 15.2 m (50 ft) of total head
e. 1520 m (5000 ft) of force main for discharge
f. field area 4478 ha (1812 ac); total area 4972 ha (2012 ac)

The 4.0 m^3/sec (100 MGD) system will include:

a. a transmission pump station with 91.2 m (300 ft) total head
b. 1520 m (5000 ft) of force main in the transmission system
c. 30,400 m (100,000 ft) of concrete channel in transmission system
d. recovery wells with 15.2 m (50 ft) of total head
e. 1520 m (5000 ft) of force main for discharge
f. field area 8958 ha (3625 ac); total area 10,041 ha (4063 ac)

The results of this comparison appear in Table 10. The results of this evaluation indicate that even with a conservative rapid infiltration design total annual costs remain much less expensive than in-plant processes capable of producing the same quality effluent.

TABLE 10. TOTAL COSTS FOR LARGE SCALE ALTERNATIVES
cents/m³ (cents/1000 gal)[a]

Alternative & Ave. Flow m³/sec (MGD)	Preliminary Treatment	Primary Sedimentation	High-Rate A/S	Biological Nitrification	Filtration	Disinfection	Sludge Handling	Mx & Lab Facilities	Const. Component Costs	Non-Const. Costs	Land Cost	Total Cost
Alternative 2												
0.4 (10)	1.5 (5.7)	0.8 (3.1)	2.7 (10.4)	2.1 (8.0)	2.5 (9.6)	0.6 (2.3)	2.1 (8.0)	1.5 (5.5)	4.7 (17.9)	4.3 (16.2)	0.0 (0.1)	22.9 (86.8)
2.0 (50)	0.8 (3.0)	0.4 (1.6)	1.6 (6.2)	1.5 (5.5)	1.5 (5.5)	0.5 (1.9)	1.5 (5.8)	1.5 (5.7)	6.1 (23.0)	4.0 (15.3)	0.0 (0.1)	19.4 (73.6)
4.0 (100)	0.7 (2.5)	0.4 (1.4)	1.4 (5.2)	1.3 (5.0)	1.2 (4.4)	0.5 (1.9)	1.3 (4.9)	1.5 (5.8)	6.3 (23.9)	3.9 (14.9)	0.0 (0.1)	18.5 (70.0)
	Preliminary Treatment	Aerated Lagoon	Transmission & Pumping	Storage	Rapid Infiltration	Surface Discharge	Disinfection	Mx & Lab Facilities	Additional Cost	Non-Const. Cost	Land Cost	Total Cost
Alternative 8												
0.4 (10)	1.5 (5.7)	0.9 (3.5)	1.5 (5.8)	0.4 (1.6)	1.6 (6.1)	0.6 (2.1)	0.3 (1.1)	0.5 (1.9)	0.3 (1.0)	1.4 (5.4)	0.8 (3.0)	9.8 (37.2)
2.0 (50)	0.8 (3.0)	0.7 (2.8)	3.2 (12.1)	0.4 (1.4)	1.5 (5.7)	0.4 (1.6)	0.2 (0.7)	0.2 (0.9)	0.2 (0.6)	1.2 (4.7)	0.7 (2.8)	9.3 (36.3)
4.0 (100)	0.7 (2.5)	0.7 (2.6)	2.5 (9.4)	0.3 (1.3)	1.5 (5.7)	0.4 (1.4)	0.2 (0.7)	0.2 (0.7)	0.1 (0.5)	0.9 (3.5)	0.7 (2.8)	8.2 (31.1)

[a]All costs adjusted to June 1979; capital costs amortized over 20 years @ 7%.
cents/1000 gal (.264) = cents/m³

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APPENDIX A

TABLE A-1. ANALYSIS RESULTS BASIN 1 (YEAR 1) - SECONDARY EFFLUENT APPLICATION

Loading date	COD (mg/ℓ) Total INF	COD (mg/ℓ) Soluble INF	COD (mg/ℓ) Total EFF	Total PO_4-P (mg/ℓ) INF	Total PO_4-P (mg/ℓ) EFF	Aver. NH_4^+-N (mg/ℓ) INF	Aver. NH_4^+-N (mg/ℓ) EFF	TKN (mg/ℓ) INF	TKN (mg/ℓ) EFF	Aver. NO_3^--N (mg/ℓ) INF	Aver. NO_3^--N (mg/ℓ) EFF	Temperature (°C) minimum INF	Temperature (°C) minimum EFF
7/12/76	-	-	11.5	-	0.08	6.80	0.23	-	-	2.58	6.8	-	16
7/19/76	57.2	-	13.4	4.8	0.11	7.00	0.55	11.5	-	1.50	8.6	-	17.5
7/26/76	61.5	-	13.6	12.8	0.15	3.5	-	-	-	3.6	8.5	20	18
8/2/76	51.0	-	11.5	4.4	0.35	6.3	-	9.86	0	2.4	8.3	20	18
8/9/76	50.8	-	9.9	4.4	0.21	-	-	-	0	3.0	7.2	19	18
8/30/76	56.7	-	9.0	6.6	0.33	6.0	0.46	11.4	-	2.1	8.9	20	18
9/6/76	54.2	-	9.2	6.4	0.30	6.8	0.47	11.6	-	2.8	8.2	20	17.5
9/13/76	61.7	-	11.3	6.8	0.71	3.5	0.18	10.8	0	2.48	6.4	19	18
9/20/76	60.4	-	17.1	6.0	1.12	3.7	0.34	12.1	0	2.3	5.1	19	18
10/11/76	67.1	-	11.4	11.6	0.18	3.6	0.85	11.9	-	2.1	11.1	18	16
10/18/76	59.6	-	6.9	8.2	0.5	3.4	0.12	11.55	0	6.4	9.7	14	12
10/25/76	63.5	-	13.0	-	1.15	2.8	-	11.6	1.12	2.5	11.7	13.5	12
11/1/76	64.3	-	8.8	9.0	0.98	3.3	-	10.1	0.90	2.1	13.2	15	12
11/8/76	68.1	50.8	13.7	9.8	1.86	8.4	-	10.4	0.89	3.7	8.3	14	12
11/29/76	76.6	42.6	14.4	8.0	0.64	7.8	0.3	11.0	-	0.8	11.2	9.5	8
12/13/76	81.2	48.7	16.3	6.8	1.09	15.0	1.64	15.5	0	-	2.9	12	7
12/20/76	94.6	66.9	16.3	3.6	0.74	4.6	0.46	-	0	1.6	13.4	10.5	7
12/27/76	69.1	46.2	14.0	6.8	1.90	4.0	-	-	-	-	-	-	5
1/3/77	95.3	50.2	27.5	14.4	2.50	15.0	0.73	-	-	1.52	10.6	-	5
2/8/77	82.4	53.7	35.4	7.0	1.33	3.5	0.10	22.9	3.2	0.1	12.5	8.5	6.5
2/15/77	241	202	44.5	7.5	0.94	18.0	0.40	24.2	1.18	0	9.9	8.5	5
2/22/77	111	54.8	25.2	8.0	1.85	12.5	0.35	23.5	1.65	0.77	12.5	12	5.5
3/1/77	131	53.2	20.0	7.3	2.05	24.0	1.18	24.2	1.6	0.57	12.3	8	5

(continued)

TABLE A-1 (continued)

Loading date	COD (mg/ℓ) Total INF	COD (mg/ℓ) Soluble INF	COD (mg/ℓ) Total EFF	Total PO_4-P (mg/ℓ) INF	Total PO_4-P (mg/ℓ) EFF	Aver. NH_4^+-N (mg/ℓ) INF	Aver. NH_4^+-N (mg/ℓ) EFF	TKN (mg/ℓ) INF	TKN (mg/ℓ) EFF	Aver. NO_3^--N (mg/ℓ) INF	Aver. NO_3^--N (mg/ℓ) EFF	Temperature (°C) minimum INF	Temperature (°C) minimum EFF
3/8/77	133	64.5	19.6	7.5	2.0	19.0	1.46	24.0	2.3	0.50	4.8	11.5	5.5
3/15/77	111	62.5	16.5	7.5	2.1	12.0	1.89	26.3	2.5	0	7.8	5	6
4/12/77	51.6	31.6	9.0	0.5	0.5	13.7	0.67	13.7	0	2.3	29.3	-	7
4/19/77	35.0	25.4	15.6	0.67	1.20	7.5	0.21	13.5	0.6	1.9	17.1	13	8
5/10/77	71.5	53.5	13.6	9.0	0.75	5.6	-	15.6	0.73	1.1	26.4	10	10
5/17/77	82.0	59.0	25.1	5.0	1.08	8.75	-	-	1.9	0.90	16.8	16	11
5/31/77	47.1	34.7	14.8	5.17	0.78	5.48	-	9.75	1.67	3.5	14.4	16.5	13
6/7/77	54.4	40.5	15.4	5.0	0.8	6.5	-	13.0	0.97	2.2	13.3	18	14
6/14/77	66.9	27.7	9.2	3.73	1.08	8.8	0.28	-	-	1.9	9.1	19	15.5
6/21/77	61.3	24.4	15.2	3.93	0.90	4.2	0.20	9.70	0.56	2.0	8.7	19	16
6/28/77	58.9	21.2	7.7	5.83	0.63	5.21	0.29	10.9	0.57	1.7	7.4	19	16
7/5/77	60.9	38.7	10.1	4.73	0.66	5.4	0.28	13.3	0.50	3.0	8.1	19.5	17.5
7/19/77	67.7	29.2	10.1	5.50	0.55	9.6	0.24	10.1	0	2.1	11.9	21	18
7/26/77	47.3	30.2	11.8	3.00	0.95	3.8	0.24	4.18	-	3.9	9.4	20	18
8/2/77	63.8	32.5	11.5	4.50	0.65	4.8	0.22	11.1	0.62	2.8	8.8	20	19
8/9/77	59.7	30.6	10.3	4.83	0.68	7.5	0.48	8.47	0	2.6	10.7	21	19
8/16/77	58.0	27.0	11.0	4.33	0.55	6.6	0.16	0.5	0	2.4	10.8	20.5	19
8/23/77	63.6	36.0	18.1	6.17	0.69	7.5	0.44	7.66	0	2.6	10.2	21	19

TABLE A-2. ANALYSIS RESULTS BASIN 1 (YEAR 1) - SECONDARY EFFLUENT APPLICATION

Loading date	Alkalinity (mg/ℓ)		Chloride (mg/ℓ)		Hardness (mg/ℓ)		Calcium (mg/ℓ)		Magnesium (mg/ℓ)		SS (mg/ℓ)		Tot. sol. (mg/ℓ)	
	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF
7/12/76	-	228	-	35.0	-	274	-	-	-	-	-	1.2	-	503
7/19/76	124	198	24.5	29.0	143	252	-	-	-	-	20.0	0	336	461
7/26/76	134	192	25.5	29.5	176	248	-	-	-	-	18.6	0	365	427
8/2/76	128	160	24.5	28.0	154	216	-	-	-	-	9.2	0	346	396
8/9/76	128	180	25.5	31.0	154	238	-	-	-	-	6.4	0	362	436
8/30/76	132	188	24.0	33.0	158	252	-	-	-	-	16.8	0	327	441
9/6/76	128	188	24.5	30.5	148	244	-	-	-	-	13.7	0	277	420
9/13/76	125	160	26.0	29.5	136	210	-	-	-	-	18.2	4.0	345	402
9/20/76	154	190	27.0	30.5	186	206	-	-	-	-	11.4	0	346	378
10/11/76	130	194	25.5	30.5	126	246	-	-	-	-	42	23	336	435
10/18/76	124	155	26.5	31.0	148	214	-	-	-	-	19	5	340	415
10/25/76	129	144	29.5	32.0	128	186	-	-	-	-	19	1.2	256	303
11/1/76	119	142	26.0	31.0	116	192	-	-	-	-	13.5	0.4	246	355
11/8/76	142	136	25.3	29.0	124	170	-	-	-	-	17	0.4	380	408
11/29/76	130	136	26.0	32.5	106	204	-	-	-	-	28	1.2	356	443
12/13/76	134	138	27.0	31.0	114	190	-	-	-	-	20	0.4	326	413
12/20/76	154	142	34.5	32.0	126	200	-	-	-	-	18	0	309	377
12/27/76	182	133	29.0	29.0	128	170	-	-	-	-	20.5	1.2	379	376
1/3/77	118	140	26.5	27.5	140	190	-	-	-	-	47	0.4	389	402
2/8/77	180	146	26.0	30.0	104	222	-	-	-	-	17.5	0.2	263	391
2/15/77	168	176	30.0	31.5	120	250	30.0	31.5	14.0	14.0	22.5	0.5	279	394
2/22/77	162	161	26.5	29.5	96	200	-	-	-	-	24	1.2	263	332
3/1/77	173	160	27.5	30.5	104	196	28	80	36	0	25.5	-	390	436
3/8/77	173	179	28.5	31.0	112	210	35	52	6	19	31.5	-	288	340
3/15/77	166	180	31.0	34.0	128	218	36	52	9.1	21.1	25.0	0	293	360

(continued)

TABLE A-2 (continued)

Loading date	Alkalinity (mg/ℓ)		Chloride (mg/ℓ)		Hardness (mg/ℓ)		Calcium (mg/ℓ)		Magnesium (mg/ℓ)		SS (mg/ℓ)		Tot. sol. (mg/ℓ)	
	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF
4/12/77	91	193	28.5	36.0	104	336	30	78	8.1	34	13.5	0.4	327	623
4/19/77	86	171	28.5	31.0	118	294	40	95	4.5	14	14.0	0.4	315	544
5/10/77	150	186	27.5	34.0	124	326	42.5	96.2	4.3	20.6	14.5	0	350	610
5/17/77	150	142	30.0	32.5	140	221	27.3	57.7	17.2	18.4	17.0	0.4	294	430
5/31/77	131	193	28.7	37.5	140	285	38.6	72.7	9.7	24.7	8.0	0	310	488
6/7/77	166	177	25.0	31.5	155	259	25.9	68.2	21.9	21.5	10.0	0	409	523
6/14/77	161	156	27.0	30.0	159	224	48.3	60.1	9.2	18.0	10.0	0	309	435
6/21/77	142	155	23.5	28.0	150	230	32.9	58.5	16.5	20.4	13.5	-	331	440
6/28/77	138	176	22.5	30.0	130	256	25.7	68.1	16.0	20.7	5.5	0	273	442
7/5/77	150	169	23.5	28.0	150	160	40.1	65.7	12.2	19.1	13.0	0	399	495
7/19/77	134	182	21.5	30.0	162	284	32.9	73.7	19.0	22.7	6.5	0	392	589
7/26/77	144	169	22.5	28.0	184	244	50	68.8	14.2	17.3	14.5	0	338	466
8/2/77	153	161	26.0	29.0	182	238	40.1	64.1	19.6	18.7	8.5	0	287	437
8/9/77	136	166	24.5	30.0	158	250	32.1	66.5	18.7	20.1	10.0	0	398	523
8/16/79	135	174	25.0	30.0	160	270	44.1	69.7	12.0	23.0	10.5	0	376	541
8/23/77	132	162	25.0	30.0	136	252	33.4	67.3	12.6	20.1	5.0	0	255	394

TABLE A-3. ANALYSIS RESULTS BASIN 1 (YEAR 2) - SECONDARY EFFLUENT APPLICATION

Loading date	COD (mg/ℓ) Total INF	COD (mg/ℓ) Soluble INF	COD (mg/ℓ) Total EFF	Total PO_4-P (mg/ℓ) INF	Total PO_4-P (mg/ℓ) EFF	Aver. NH_4^+-N (mg/ℓ) INF	Aver. NH_4^+-N (mg/ℓ) EFF	TKN (mg/ℓ) INF	TKN (mg/ℓ) EFF	Aver. NO_3^--N (mg/ℓ) INF	Aver. NO_3^--N (mg/ℓ) EFF	Temperature (°C) minimum INF	Temperature (°C) minimum EFF
9/6/77	68.1	-	8.9	6.2	0.55	5.85	0.12	7.48	1.12	2.69	12.7	21	21
9/13/77	65.0	55.8	15.5	6.4	0.74	7.26	0.25	15.6	0.64	2.72	12.3	19.5	20
9/20/77	67.3	48.4	12.4	7.3	0.89	5.50	0.07	19.4	0.52	2.93	12.7	19	19
9/27/77	71.6	49.9	11.8	7.0	1.01	5.50	0.04	15.9	1.39	3.5	11.8	18	19
10/4/77	69.7	55.6	12.2	6.8	1.10	8.38	0.27	8.49	0.50	4.6	11.8	17	17
10/11/77	82.6	54.3	10.4	6.7	1.18	7.85	0.22	10.8	0.74	1.1	12.6	14	15
11/1/77	80.0	56.3	9.8	6.7	0.86	8.71	0.20	5.65	0.71	4.5	16.0	13	14
11/8/77	74.8	53.4	11.4	6.7	1.55	7.59	0.16	13.9	0.60	5.9	14.0	11.5	12
11/15/77	78.0	59.8	32.8	7.3	1.78	10.0	0.20	11.25	0.66	4.3	11.9	14	11
11/22/77	90.0	52.6	9.6	6.7	1.45	5.62	0.19	13.3	0.74	1.6	13.6	11.5	10
11/29/77	72.0	48.4	10.6	7.7	2.0	8.78	0.26	20.8	0.77	4.6	15.1	12	10
12/13/77	85.6	54.8	11.2	7.0	2.1	9.57	0.39	20.8	1.47	4.1	14.7	10.5	8
1/17/78	76.2	43.4	20.2	6.2	2.9	10.9	0.36	7.41	4.35	1	8.5	8	5
1/31/78	-	35	13	7.0	2.8	15.3	0.72	20.2	3.84	2.4	10.7	9	3.5
2/7/78	67	45	14	7.8	2.4	3.8	1.02	7.4	0.71	1.7	14.6	10	4.5
2/14/78	85	71	17	6.8	2.7	7.0	1.12	10.6	0.68	2.2	13.0	8	3.5
2/21/78	77	44	10	6.2	1.9	15.1	1.48	-	-	1.8	15.0	9	3.5
3/21/78	73.0	48.4	10.0	8.8	2.4	17.1	0.47	-	-	2.7	35.4	11	7
3/28/78	75.5	56.6	12.8	7.0	3.6	6.28	0.19	-	-	2.3	16.3	12.5	8.5
4/11/78	92.9	51.1	17.1	5.9	4.3	10.0	0.41	-	-	4.8	5.9	11.5	10.5
4/18/78	85.1	56.8	19.2	5.9	3.9	5.34	0.95	-	-	5.1	2.6	10.0	10
4/25/78	62.2	45.7	20.2	5.6	2.7	10.2	1.21	-	-	1.7	0.6	13.5	11
6/13/78	58.0	42.9	17.2	4.0	0.9	2.8	0.15	-	-	1.5	15.2	-	12
6/20/78	60.9	25.4	16.3	3.7	0.8	6.7	0.26	-	-	2.4	10.0	16	14
6/27/78	50.5	35.4	-	3.4	-	7.1	0.39	-	-	2.1	9.3	18	16

TABLE A-4. ANALYSIS RESULTS BASIN 1 (YEAR 2) - SECONDARY EFFLUENT APPLICATION

Loading date	Alkalinity (mg/ℓ)		Chloride (mg/ℓ)		Hardness (mg/ℓ)		Calcium (mg/ℓ)		Magnesium (mg/ℓ)		SS (mg/ℓ)		Tot. sol. (mg/ℓ)	
	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF
9/6/77	138	187	25	31	142	288	44	80	7.7	21.1	24.6	0.0	354	549
9/13/77	126	174	25.0	30.5	132	260	52	68	0.48	21.6	8.9	0.0	293	468
9/20/77	136	168	24	29.5	128	250	48	68.8	1.9	18.7	13.2	0.0	330	460
9/27/77	142	162	23.5	30	130	248	38.4	80	8.2	11.5	18.0	0.0	326	465
10/4/77	120	168	25.5	30	124	240	44	72	3.4	14.4	11.0	0.0	356	482
10/11/77	122	151	25	31.5	118	232	31.2	68.4	9.6	18.2	13.3	0.0	340	465
11/1/77	121	173	32.5	22.5	108	286	30.4	74	7.7	24.5	13.8	0.0	313	529
11/8/77	115	169	27.5	28.5	104	124	24.8	58.4	10.1	18.7	21.5	1.0	281	428
11/15/77	128	136	22.5	27.5	98	212	28	71.5	6.9	8.2	12.5	3.0	281	412
11/22/77	119	165	30.5	34.0	132	256	35	81	11	13	18.2	0.0	324	488
11/29/77	134	138	29.0	29.5	96	210	27.2	64.0	6.7	12	13.6	2.0	316	443
12/13/77	121	147	30	34	100	242	27	64	7.8	20	9	2.5	226	409
1/17/78	144	127	34.5	32.4	104	184	34	54	4.4	11.7	8	2	150	170
1/31/78	143	103	-	-	98	198	28	56	6.8	14.2	13	1	160	232
2/7/78	154	142	31	36	100	204	29	54	6.8	17.0	76	17	351	429
2/14/78	152	144	32	31	84	104	27	59	3.9	-	28	5	341	428
2/21/78	185	113	29	30	110	208	28	57	9.8	16.1	16	2	344	425
3/21/78	171	151	29.5	30.5	104	252	30.4	74.4	6.8	16.1	21	2	355	520
3/28/78	166	155	23	28	114	237	32	64	8.3	18.8	21	4	345	478
4/11/78	143	139	27	26	120	188	30	52	11.7	14.2	40.0	2	409	410
4/18/78	122	137	27	28	120	188	33.7	52.9	6.3	11.7	17.0	0.0	370	368
4/25/78	153	142	37	28	124	174	33	54	10.2	9.8	7	0.5	346	383
6/13/78	135	155	25	29	144	286	44	85	8.3	17.8	8	5	324	463
6/20/78	125	143	23	30	190	282	50	71	17.6	25.6	13	6	281	450
6/27/78	127	-	21	-	141	-	33.7	-	13.9	-	10	-	307	-

TABLE A-5. ANALYSIS RESULTS BASIN 1 (YEAR 3) - PRIMARY EFFLUENT APPLICATION

Loading date	COD (mg/ℓ) Total INF	COD (mg/ℓ) Soluble INF	COD (mg/ℓ) Total EFF	Total PO_4-P (mg/ℓ) INF	Total PO_4-P (mg/ℓ) EFF	Aver. NH_4^+-N (mg/ℓ) INF	Aver. NH_4^+-N (mg/ℓ) EFF	TKN (mg/ℓ) INF	TKN (mg/ℓ) EFF	Aver. NO_3^--N (mg/ℓ) INF	Aver. NO_3^--N (mg/ℓ) EFF	Temperature (°C) minimum INF	Temperature (°C) minimum EFF
11/7/78	269	205	15.6	6.3	0.31	-	-	-	0.35	0	27.2	15	14
11/14/78	183	109	13	4.8	0.30	5.21	0.36	-	-	0.3	18.6	13	11
11/21/78	160	105	13	5.2	0.41	12.8	0.09	-	-	0.2	12.7	13	9
11/28/78	345	239	20	4.8	0.39	12.9	0.05	8.1	0.35	0.3	11.9	13	11
1/23/79	107	40.7	15.1	3.7	0.38	13.0	-	16.4	0.24	1.0	-	10	6
1/30/79	277	175	36	5.0	0.57	7.0	0.14	13.4	2.2	0.8	4.2	6	4
2/6/79	181	70.3	20.8	7.6	0.85	13.5	0.65	23.4	2.25	0.6	2.4	10	5
2/13/79	153	60.1	17.4	4.4	0.47	13.0	2.2	19.0	2.27	0.6	5.6	10	5
2/20/79	172	68.6	12.4	7.7	0.51	18.0	0.63	20.3	1.55	0.2	5.8	9	5
2/27/79	154	52	15.5	7.9	0.55	22.0	0.40	19.5	1.21	0.0	4.8	10	5
4/3/79	89	29	8.7	2.8	0.40	6.7	0.29	13.4	1.34	1.0	28.0	9	6
4/10/79	-	-	6	-	0.41	-	-	-	0.24	-	-	-	7
4/17/79	89	28	8	2.3	0.55	6.2	0.10	12.3	0.24	0.3	27.2	13	8
4/24/79	120	52	8	2.6	0.58	5.4	0.15	13.5	0.61	0.0	16.5	12.5	9
5/1/79	79	30	11	2.6	0.62	7.3	0.23	11.2	0.85	0.9	15.2	13	9
5/8/79	-	-	10	-	0.61	-	0.10	-	0.61	-	14.3	-	9
5/22/79	79.5	28.5	10.2	1.6	0.47	4.7	0.12	8.5	0.12	3.4	14.2	13.5	11
5/29/79	73.2	27.0	11.9	2.0	0.53	5.6	0.10	9.0	0.53	2.2	13.3	14	11
6/5/79	72.2	26.5	11.1	1.3	0.56	4.5	0.05	7.2	0.59	1.6	8.7	15	12
6/12/79	101.4	39.8	7.8	1.8	0.57	4.8	0.06	12.2	0.47	3.8	9.8	17	12
6/19/79	113.6	46.2	9.2	2.1	0.58	4.9	0.08	10.6	0.73	2.5	7.7	15	12
6/26/79	170.0	125.7	8.7	2.7	0.60	9.8	0.07	20.8	0.60	1.8	5.6	17.5	14
7/10/79	76.4	31.8	12.0	2.4	0.46	5.2	0.06	9.7	0.0	1.6	11.0	18	14
7/17/79	217.2	40.7	10.7	4.9	0.50	5.3	0.05	19.2	0.48	0.6	12.8	20	14
7/24/79	40.1	24.8	10.9	2.1	0.51	10.7	0.12	8.8	0.40	2.2	12.7	20	15
7/31/79	74.1	31.5	8.3	2.2	0.54	5.3	0.10	8.6	0.0	1.3	12.7	19	15

(continued)

TABLE A-5 (continued)

Loading date	COD (mg/ℓ) Total INF	COD (mg/ℓ) Soluble INF	COD (mg/ℓ) Total EFF	Total PO_4-P (mg/ℓ) INF	Total PO_4-P (mg/ℓ) EFF	Aver. NH_4^+-N (mg/ℓ) INF	Aver. NH_4^+-N (mg/ℓ) EFF	TKN (mg/ℓ) INF	TKN (mg/ℓ) EFF	Aver. NO_3^--N (mg/ℓ) INF	Aver. NO_3^--N (mg/ℓ) EFF	Temperature (°C) minimum INF	Temperature (°C) minimum EFF
8/7/79	67.9	36.6	12.7	1.4	0.56	4.6	0.04	6.8	0.24	2.2	9.7	20	16
8/14/79	55.1	22.6	8.8	1.7	0.60	4.1	0.03	8.0	0.24	2.1	9.2	17	16
8/28/79	63.4	21.5	9.3	2.4	0.49	5.6	0.07	6.9	0.6	1.4	9.1	19	16
9/4/79	45.3	22.0	13.7	2.5	0.52	6.6	0.14	7.6	0.9	1.1	9.6	19.5	16.5
9/11/79	78.4	24.9	8.2	2.5	0.53	8.0	0.12	11.1	0.1	0.9	10.3	19.5	16.5
9/18/79	99.2	33.9	11.5	2.8	0.59	9.15	0.17	13.2	0.4	0.9	10.6	19	16
9/25/79	84.5	30.5	8.7	3.0	0.55	9.13	0.13	12.2	0.0	0.6	10.4	18.5	16
10/2/79	147	86.3	7.4	3.8	0.61	10.0	0.17	18.3	0.4	0.6	9.3	19	16

TABLE A-6. ANALYSIS RESULTS BASIN 1 (YEAR 3) - PRIMARY EFFLUENT APPLICATION

Loading date	Alkalinity (mg/ℓ)		Chloride (mg/ℓ)		Hardness (mg/ℓ)		Calcium (mg/ℓ)		Magnesium (mg/ℓ)		SS (mg/ℓ)		Tot. sol. (mg/ℓ)	
	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF
11/7/78	447	178	31.1	37.8	218	474	87.0	189.5	19	7	157	6.2	988	789
11/14/78	182	168	24	37	205	381	65	112	10	24	45.0	1.8	488	650
11/21/78	169	166	26	36	173	324	53	100	10	18	38.0	2.0	303	472
11/28/78	163	173	33	39	154	342	54	109	4	17	60	5.4	635	729
1/23/79	165	166	23.6	33.0	199	353	53	94	16	29	28.5	0.6	381	544
1/30/79	223	159	28.4	33.3	227	297	74.7	92.7	10	16	73	1.1	453	518
2/6/79	246	201	31.3	31.6	207	264	62.4	76.6	12.4	17.8	144	25.8	463	421
2/13/79	157	191	29.9	33.8	168	336	48	95	12	24	30.5	0.8	414	571
2/20/79	163	204	31.8	33.3	136	346	34	103	12	22	59.0	2.3	463	572
2/27/79	188	205	34.9	33.5	168	346	48.5	95	11	26	91	2.7	419	526
4/3/79	163	194	28	35	226	439	58	131	20	27	34	0.5	438	735
4/10/79	-	184	-	34	-	413	-	119	-	28	-	2.1	-	650
4/17/79	179	167	30	33	257	384	77	107	16	28	37	0.7	421	588
4/24/79	203	172	29	34	266	361	73	108	20	22	41	0.9	449	566
5/1/79	172	177	28	34	247	361	70	108	18	22	24	1.0	418	590
5/8/79	-	178	-	31	-	342	-	98	-	24	-	0.8	-	543
5/22/79	181	194	28	32	297	400	82	113	22	29	31	1.2	515	-
5/29/79	185	191	32.3	35.2	273	386	67.9	111	25.3	26.2	25.5	1.5	450	616
6/5/79	174	200	31.4	34.9	290	386	71.6	102.8	27.0	31.6	36.5	1.2	467	582
6/12/79	224	196	29.3	34.9	333	389	92.3	105.8	25.0	30.4	49.0	2.4	493	567
6/19/79	192	199	28	30.2	297	389	78.8	112	24.3	27.0	55.5	0.4	504	601
6/26/79	230	203	23.1	30.0	276	384	75.0	101.9	21.6	31.6	122.0	0.4	526	584
7/10/79	225	209	22.4	33.0	302	434	81.7	127.9	24.0	27.9	42.0	2.5	473	648
7/17/79	171	205	27.8	32.0	218	401	54.8	108.6	19.9	31.6	145	0.7	561	665
7/24/79	183	200	20.3	30.7	276	403	74.4	107	21.9	33.3	20.0	0.3	447	632
7/31/79	181	204	20.5	30.4	245	393	62.5	103.8	21.6	32.6	23.0	0.7	353	573

(continued)

TABLE A-6. (continued)

Loading date	Alkalinity (mg/ℓ)		Chloride (mg/ℓ)		Hardness (mg/ℓ)		Calcium (mg/ℓ)		Magnesium (mg/ℓ)		SS (mg/ℓ)		Tot. sol. (mg/ℓ)	
	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF
8/7/79	178	206	21.7	29.7	262	391	64.7	106.8	24.5	30.1	16.0	0.0	434	611
8/14/79	187	211	22.2	29.7	264	391	66.7	105.9	23.8	39.9	17.0	0.2	422	611
8/28/79	168	215	21.2	31.6	254	409	62.5	114	23.8	30.6	23	1.1	431	631
9/14/79	169	209	21.1	29.7	245	393	63.5	114	21.1	26.2	24.5	0.9	439	618
9/11/79	165	212	19.4	26.7	202	328	52.9	96.7	17.0	21.1	31.5	0.4	453	630
9/18/79	167	211	20.5	28.1	188	335	49.0	94.8	16.0	23.8	32.0	0.8	535	641
9/25/79	160	208	21.2	27.6	184	333	52.3	94.8	12.9	23.3	28.5	1.1	405	579
10/2/79	226	209	21.2	27.6	234	323	77.1	98.1	10.2	19.0	28.0	0.6	518	588

TABLE A-7. ANALYSIS RESULTS BASIN 2 (YEAR 1) - SECONDARY EFFLUENT APPLICATION

Loading date	COD (mg/ℓ) Total INF	COD (mg/ℓ) Soluble INF	COD (mg/ℓ) Total EFF	Total PO_4-P (mg/ℓ) INF	Total PO_4-P (mg/ℓ) EFF	Aver. NH_4^+-N (mg/ℓ) INF	Aver. NH_4^+-N (mg/ℓ) EFF	TKN (mg/ℓ) INF	TKN (mg/ℓ) EFF	Aver. NO_3^--N (mg/ℓ) INF	Aver. NO_3^--N (mg/ℓ) EFF	Temperature (°C) minimum INF	Temperature (°C) minimum EFF
7/13/76	64.1	-	14.8	4.0	0.05	6.1	0.87	9.4	-	2.20	3.2	-	15
7/20/76	60.4	-	16.9	4.8	0.20	9.2	0.86	-	-	3.12	2.0	20	16
7/27/79	51.6	-	16.0	5.2	0.21	5.4	-	-	-	2.92	1.2	-	17
8/3/79	51.0	-	15.3	5.0	0.13	6.3	-	3.0	0	2.42	0.43	20	17.5
8/24/76	56.5	-	14.6	7.4	0.12	3.4	0.15	-	0	1.64	2.5	20	17
8/31/76	61.3	-	13.6	7.0	0.10	6.2	0.31	12.3	-	1.32	0.94	20	17
9/7/76	69.6	-	15.4	6.3	0.08	10.0	0.34	15.6	0.6	1.80	0.48	20.5	18
9/14/76	65.4	-	13.3	8.0	0.14	3.95	0.11	11.7	0	1.84	0.39	20	17
10/12/76	68.8	-	12.2	5.0	0.05	3.3	1.5	11.8	-	2.6	2.4	17	15
10/19/76	61.6	-	22.0	8.0	0.21	3.45	0.10	12.4	-	3.5	2.1	14	12
10/26/76	79.1	-	12.2	7.6	0.25	3.1	0.11	13.6	1.12	2.40	2.5	14.5	12
11/2/76	75.1	-	13.1	6.8	0.35	4.3	0.08	13.6	1.01	1.4	2.7	15	11
11/30/76	86.6	52.2	22.4	8.0	0.30	6.7	-	10.8	-	1.14	9.7	11	8
4/13/77	45.6	32.6	7.8	0.80	0.06	11.0	0.53	14.9	0	2.4	8.6	12	7
4/20/77	39.2	12.4	12.4	1.30	0.75	4.8	0.15	8.5	0.60	1.8	8.3	11.5	8
4/27/77	53.2	29.6	8.54	3.83	0.25	8.8	0.12	14.5	0.59	1.2	7.7	14	9
5/4/77	49.2	-	8.1	1.0	0.07	9.6	0.12	14.6	0.66	0.17	8.5	14	9
5/18/77	67.2	47.2	7.1	5.0	0.02	7.46	0.05	13.6	0.11	1.2	11.0	11	11
6/1/77	60.6	44.4	8.8	5.73	0.05	5.95	0.10	10.2	0	1.6	12.3	17	12
6/8/77	53.6	34.7	18.9	5.0	0.13	5.8	0.28	11.1	0.84	2.2	11.1	19	13
6/15/77	51.7	22.0	3.8	5.0	0.10	2.3	0.09	8.57	0.85	2.3	9.1	18	15
6/22/77	60.5	27.9	12.7	4.83	0.05	5.43	0.06	10.7	0.34	1.8	7.8	18	14
6/29/77	56.0	23.2	5.5	5.0	0.08	5.89	0.12	11.5	0.57	2.1	6.1	20	16
7/6/77	64.5	42.6	4.7	4.97	0.28	6.1	0.04	11.7	0	2.0	7.1	19.5	16

(continued)

TABLE A-7 (continued)

Loading date	COD (mg/ℓ) Total INF	COD (mg/ℓ) Total EFF	COD (mg/ℓ) Soluble Total INF	Total PO_4-P (mg/ℓ) INF	Total PO_4-P (mg/ℓ) EFF	Aver. NH_4^+-N (mg/ℓ) INF	Aver. NH_4^+-N (mg/ℓ) EFF	TKN (mg/ℓ) INF	TKN (mg/ℓ) EFF	Aver. NO_3^--N (mg/ℓ) INF	Aver. NO_3^--N (mg/ℓ) EFF	Temperature (°C) minimum INF	Temperature (°C) minimum EFF
7/20/77	58.4	26.1	7.8	4.93	0.05	7.8	0.15	9.7	4.1	2.7	5.8	21	16
7/27/77	49.6	23.0	7.5	3.73	0.08	4.0	0.17	4.6	0.41	4.0	6.3	21	16
8/2/77	58.7	27.9	8.7	3.17	0.06	5.7	0.06	15.5	0.90	2.8	5.0	20	16
8/10/77	58.1	32.8	6.5	4.67	0.06	7.2	0.34	8.8	0	2.8	6.5	20	17
8/17/77	56.8	26.0	7.6	4.93	0.07	6.9	0.14	19.0	2.0	2.9	5.8	20	17
8/24/77	66.3	37.0	8.7	4.9	0.10	6.2	0.22	8.3	0	2.4	6.8	20	17

TABLE A-8. ANALYSIS RESULTS BASIN 2 (YEAR 1) - SECONDARY EFFLUENT APPLICATION

Loading date	Alkalinity (mg/ℓ)		Chloride (mg/ℓ)		Hardness (mg/ℓ)		Calcium (mg/ℓ)		Magnesium (mg/ℓ)		SS (mg/ℓ)		Tot. sol. (mg/ℓ)	
	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF
7/13/76	128	226	25.0	44.5	152	300	-	-	-	-	18.6	0	399	547
7/20/76	102	204	23.5	33.5	152	254	-	-	-	-	11.6	0	346	484
7/27/76	134	184	23.5	31.0	162	234	-	-	-	-	12.6	3.4	334	439
8/3/76	142	192	35.0	34.5	184	235	-	-	-	-	14.4	0	399	432
8/24/76	130	213	38.5	38.5	146	254	-	-	-	-	14.6	0	359	462
8/31/76	132	202	36.0	38.0	142	244	-	-	-	-	10.6	0	349	434
9/7/76	164	208	26.5	35.5	170	240	-	-	-	-	21.6	0	346	403
9/14/76	140	200	32.5	35.0	140	228	-	-	-	-	16.4	1.4	373	435
10/12/76	75	235	28	33	122	262	-	-	-	-	34	17	320	450
10/19/76	122	198	34.0	35.5	116	236	-	-	-	-	17	5	335	425
10/26/76	133	179	41.5	37.0	114	202	-	-	-	-	20	0.6	291	326
11/2/76	126	176	34.0	36.0	110	196	-	-	-	-	13	0.4	318	372
11/30/76	117	185	34.5	36.5	98	236	-	-	-	-	23	1.2	397	465
4/13/77	83	198	28.5	43.5	100	326	26	76	8.4	32.6	11.5	0	322	577
4/20/77	99	183	25.5	38.0	144	300	37	88	12.5	19	16.5	0	331	535
4/27/77	120	149	25.5	30.5	132	280	45	75	4.8	22	29	0.4	245	349
5/4/77	96	153	30.0	32.5	140	266	30.5	65.7	15.3	24.4	7.0	0	357	457
5/18/77	139	167	25.5	32.5	122	244	30.5	67.3	11.0	18.2	13.0	0	274	389
6/1/77	139	158	27.5	33.7	132	261	34.1	72.3	11.0	19.3	6.0	0	301	464
6/8/77	142	154	26.5	31.0	140	241	33.4	63.0	13.8	20.3	13.0	0	388	525
6/15/77	128	151	26.0	36.0	143	226	45.2	64.5	7.3	15.1	13.0	0	313	419
6/22/77	131	155	22.0	32.5	134	218	30.5	56.1	14.1	18.9	13.0	0	339	476
6/29/77	134	141	23.0	26.0	136	200	36.1	52.1	11.1	16.0	5.0	0	254	347
7/6/77	134	152	24.5	28.0	140	206	32.1	52.9	14.5	17.9	13.5	0	346	412

(continued)

TABLE A-8. (continued)

Loading date	Alkalinity (mg/ℓ)		Chloride (mg/ℓ)		Hardness (mg/ℓ)		Calcium (mg/ℓ)		Magnesium (mg/ℓ)		SS (mg/ℓ)		Tot. sol. (mg/ℓ)	
	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF
7/20/77	126	167	20.5	28.5	147	206	36.1	60.0	13.4	13.4	13.0	0	351	452
7/27/77	148	181	21.5	27.5	176	220	44.0	57.6	15.8	18.2	14.0	0	390	445
8/3/77	151	170	26.5	28.0	186	220	44.1	54.5	18.2	20.1	6.0	0	309	355
8/10/77	131	160	22.7	29.0	150	210	36.1	56.1	14.3	16.7	9.0	0	392	468
8/17/77	126	139	25.0	28.0	140	212	32.1	49.7	14.3	21.6	11.5	0	362	440
8/24/77	119	142	26.5	29.0	142	200	36.1	49.7	12.4	18.2	6.0	0	268	328

TABLE A-9. ANALYSIS RESULTS BASIN 2 (YEAR 2) -SECONDARY EFFLUENT APPLICATION

Loading date	COD (mg/ℓ) Total INF	COD (mg/ℓ) Soluble INF	COD (mg/ℓ) Total EFF	Total PO_4-P (mg/ℓ) INF	Total PO_4-P (mg/ℓ) EFF	Aver. NH_4^+-N (mg/ℓ) INF	Aver. NH_4^+-N (mg/ℓ) EFF	TKN (mg/ℓ) INF	TKN (mg/ℓ) EFF	Aver. NO_3^--N (mg/ℓ) INF	Aver. NO_3^--N (mg/ℓ) EFF	Temperature (°C) minimum INF	Temperature (°C) minimum EFF
9/7/77	74.0	54.7	11.7	7.3	0.09	5.94	0.21	5.13	0.81	2.2	7.3	21	16
9/14/77	63.0	53.9	14.6	5.9	0.09	7.26	0.32	14.4	0.59	3.1	10.0	18.5	16
9/21/77	72.6	48.6	9.4	7.1	0.17	5.75	0.06	20.2	0.61	3.5	12.3	19	15.5
9/28/77	71.3	53.2	8.5	6.7	0.18	5.75	0.07	10.5	0.32	3.7	11.8	18.5	15
10/5/77	68.5	55.9	11.7	7.0	0.19	8.38	0.11	6.23	0.55	4.8	11.1	17.5	14.5
11/2/77	83.7	53.1	9.4	7.0	0.19	7.59	0.10	10.5	0.71	5.2	12.6	14	12.5
11/9/77	80.6	49.2	13.0	6.7	0.18	7.59	0.14	11.8	0.55	5.2	13.8	10.5	11.5
11/16/77	77.4	53.8	19.4	6.8	0.27	9.54	0.24	15.6	0.64	5.0	12.4	12	10.5
11/23/77	88.0	52.6	6.8	7.3	0.28	5.10	0.18	15.3	0.62	3.5	12.0	11	9.5
11/30/77	77.4	48.4	7.4	6.5	0.38	8.78	0.26	17.5	0.84	4.1	13.9	11.5	9
12/7/77	90.0	56.8	10.8	7.7	0.75	12.3	0.25	15.9	0.75	3.8	14.3	11.5	8.5
12/14/77	88.0	56.8	22.8	7.3	0.39	8.87	0.45	10.9	2.08	4.2	14.5	12.5	8.5
1/18/78	73.2	38.0	27.4	6.5	0.7	6.26	0.45	13.2	1.53	3.0	11.5	4	4
2/1/78	58	33	13	7.4	1.0	16.0	1.56	20.2	7.26	2.5	11.4	6	3.5
2/8/78	67	45	13	7.0	1.0	13.0	1.62	11.6	0.68	1.5	10.0	10	5
2/15/78	70	49	11	8.0	1.2	14.3	1.27	8.4	0.78	1.9	11.6	7.5	4.5
2/22/78	68	32	9	5.6	1.1	15.5	1.10	-	-	2.1	14.4	9	4.5
3/22/78	68.7	51.1	9.6	9.3	0.6	17.2	0.47	-	-	2.6	25.4	12	6.5
3/29/78	72.0	59.9	11.8	6.9	1.4	5.93	0.52	-	-	2.3	13.6	13	8
4/12/78	76.0	49.5	16.5	5.5	2.5	10.0	0.45	-	-	4.8	11.5	12	9
4/19/78	88.4	55.5	-	6.1	-	8.60	0.18	-	-	4.0	14.5	12	9
4/26/78	68.5	52.2	9.2	6.1	1.0	10.2	0.15	-	-	2.6	14.4	13.5	9.5
6/14/78	55.0	37.5	17.8	6.3	0.68	3.0	0.39	-	-	1.9	14.9	-	10.5
6/21/78	54.4	25.8	11.2	3.6	0.65	6.1	0.46	-	-	1.9	10.6	17	13.5
6/28/78	51.7	37.2	7.5	3.5	0.65	6.6	0.68	-	-	2.1	8.2	18	16

TABLE A-10. ANALYSIS RESULTS BASIN 2 (YEAR 2) - SECONDARY EFFLUENT APPLICATION

Loading date	Alkalinity (mg/ℓ)		Chloride (mg/ℓ)		Hardness (mg/ℓ)		Calcium (mg/ℓ)		Magnesium (mg/ℓ)		SS (mg/ℓ)		Tot. sol. (mg/ℓ)	
	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF
9/7/77	140	167	24	27.5	130	204	44	60	4.8	13.0	30.0	0	320	390
9/14/77	128	129	24.5	27.5	130	208	39.2	53.6	7.7	17.8	13.7	0	325	377
9/21/77	137	138	23.5	26.5	126	198	42.4	58.4	4.8	12.5	14.2	0	322	397
9/28/77	146	181	25	27.5	134	250	36	73.6	10.1	15.8	18.6	0	326	437
10/5/77	119	144	24	29.5	120	208	38.4	58.4	5.8	14.9	8.0	0	335	438
11/2/77	114	156	23.0	31.5	112	214	25.6	62.4	11.5	13.9	14.5	0	319	397
11/9/77	112	87	23.5	27.0	110	186	24.8	48	11.5	15.8	13.3	3.3	288	413
11/16/77	110	131	23.5	26.5	84	184	25.6	54.4	4.8	11.5	12.3	-	291	380
11/23/77	118	108	26.5	27.5	98	164	30.4	46.4	5.3	11.5	19.5	0	301	384
11/30/77	121	129	26	28.5	86	178	31.2	53.6	1.9	10.6	19.5	3.0	312	392
12/7/77	128	122	28	30.5	92	176	29.6	49.6	4.4	12.7	17.2	4.8	375	320
12/14/77	118	135	26.5	30.5	90	186	26.4	83.2	6	-	13.5	11.5	400	295
1/18/78	121	46	45	16	108	102	28	20	38	54.2	11	3	-	-
2/1/78	135	110	-	-	94	164	26	42	7.3	14.6	15	6	157	196
2/8/78	168	107	24	27	102	154	31	38	5.9	14.6	42	16	341	353
2/15/78	144	101	28	28	86	146	30	40	2.9	11.2	26	6	323	350
2/22/78	126	117	28	29	100	166	30	42	5.9	15.1	16	1	328	362
3/22/78	172	130	28	28.5	112	184	30.4	51.2	8.8	13.7	25	0	337	402
3/29/78	156	102	24	29.5	94	174	30.5	48.1	4.4	13.2	16	1	321	357
4/12/78	143	87	26.5	26.5	126	130	41	38	5.9	8.8	15	1	350	360
4/19/78	136	-	24.5	-	118	-	35	-	7.3	-	21	-	353	-
4/26/78	162	102	27	23	104	156	38	38	2	14.6	9	0	310	372
6/14/78	129	108	23	25	161	181	52	52	7.6	13.4	8	7	305	318
6/21/78	-	108	22.5	26.5	184	200	48	52	15.6	17.1	9	4	294	351
6/28/78	149	114	21	25.5	170	144	46	42.5	13.4	9.3	8	3	296	389

TABLE A-11. ANALYSIS RESULTS BASIN 2 (YEAR 2) - PRIMARY EFFLUENT APPLICATION

Loading date	COD (mg/ℓ) Total INF	COD (mg/ℓ) Soluble INF	COD (mg/ℓ) Total EFF	Total PO_4-P (mg/ℓ) INF	Total PO_4-P (mg/ℓ) EFF	Aver. NH_4^+-N (mg/ℓ) INF	Aver. NH_4^+-N (mg/ℓ) EFF	TKN (mg/ℓ) INF	TKN (mg/ℓ) EFF	Aver. NO_3^--N (mg/ℓ) INF	Aver. NO_3^--N (mg/ℓ) EFF	Temperature (°C) minimum INF	Temperature (°C) minimum EFF
11/15/78	183	123	16	4.8	0.65	10.0	0.51	-	-	0.3	12.0	11	11
11/22/78	263	203	27	5.5	0.88	-	-	-	-	-	-	-	10
11/29/78	-	-	20	-	0.60	-	-	-	-	-	-	-	10
1/24/79	151	58.2	22.1	3.8	0.39	17.0	1.53	19.0	0.30	0.8	10.1	8	4
1/31/79	250	99	35.8	5.4	1.07	11.2	3.44	18.6	2.7	0.9	3.3	8	4
2/7/79	146	43.7	16.8	4.8	0.92	6.0	2.0	16.6	1.89	1.0	3.1	8	5
2/14/79	155	64	22.7	4.7	0.47	19.0	3.5	17.8	1.2	0.6	2.1	10	5
2/21/79	184	76.4	-	4.6	-	18.0	2.2	20.7	-	0.5	3.4	10	6
2/28/79	169	71	27.7	5.0	1.10	19.5	1.7	20.6	3.14	0.1	3.7	9	5
4/4/79	158	66.5	13.5	3.1	0.75	7.0	1.14	19.2	2.44	1.2	31.8	11	7
4/11/79	177	72	15	2.5	0.75	8.6	1.14	17.1	1.10	1.3	8.3	9	7
4/18/79	134	44	15	3.2	0.77	7.7	0.88	15.3	2.8	0.8	13.4	12.5	10
4/25/79	124	63	26	2.8	1.2	4.7	0.68	12.2	2.2	1.1	11.4	13	9
5/2/79	89	28	17	1.9	1.2	5.0	0.85	11.5	1.83	1.1	10.4	11	10
5/9/79	77	38	14	1.3	0.94	2.4	0.63	9.9	0.85	2.1	9.2	10	10
5/23/79	79.5	37.9	11.8	2.5	0.69	7.6	0.69	15.9	0.97	1.8	10.5	14	11
5/30/79	134.8	48.2	13.7	2.3	0.44	6.0	0.69	13.6	1.29	2.6	14.2	13	10
6/6/79	69.6	26.7	9.4	1.3	0.40	4.8	0.32	7.17	0.89	2.0	12.3	15	11.5
6/13/79	83.4	21.6	10.5	1.5	0.79	3.5	0.42	8.0	0.82	2.1	9.5	15	12
6/20/79	104	55.9	13	1.5	0.93	5.0	0.46	8.6	0.73	1.9	5.8	15.5	12.5
6/27/79	125.7	39.3	9.7	1.6	0.47	5.2	0.34	12.1	0.96	1.1	7.8	17	13.5
7/11/79	63.0	25.1	13.4	1.6	0.53	3.9	0.48	7.4	0.61	1.4	12.8	18	14
7/18/79	90	27.5	12.8	1.9	0.59	4.1	0.59	8.1	0.48	1.0	9.1	18	15
7/25/79	82.6	38.3	13.0	3.3	0.63	6.3	0.54	9.6	0.40	0.6	14.4	19	15
8/1/79	95.0	23.7	12.7	2.2	0.78	5.4	0.59	8.7	0.60	1.4	9.8	18	15
8/8/79	58.4	26.3	10.6	1.5	0.47	4.5	0.40	6.3	0.24	2.2	12.9	21	16
8/15/79	53.0	18.4	11.0	1.3	0.67	3.3	0.39	6.4	0.24	2.7	11.2	18	16

(continued)

TABLE A-11 (continued)

Loading date	COD (mg/ℓ) Total INF	COD (mg/ℓ) Soluble INF	COD (mg/ℓ) Total EFF	Total PO_4-P (mg/ℓ) INF	Total PO_4-P (mg/ℓ) EFF	Aver. NH_4^+-N (mg/ℓ) INF	Aver. NH_4^+-N (mg/ℓ) EFF	TKN (mg/ℓ) INF	TKN (mg/ℓ) EFF	Aver. NO_3^--N (mg/ℓ) INF	Aver. NO_3^--N (mg/ℓ) EFF	Temperature (°C) minimum INF	Temperature (°C) minimum EFF
9/29/79	69.1	22.4	12.2	2.1	0.51	5.7	0.40	7.5	1.2	1.2	13.3	19.5	15.5
9/5/79	169.7	66.1	14.1	3.7	0.77	9.3	0.87	22.7	1.2	0.8	8.2	20.5	16
9/21/79	77.1	31.2	11.4	2.9	0.72	7.8	0.80	11.7	0.2	0.9	10.1	18	16
9/19/79	86.3	29.3	16.6	2.5	0.92	8.8	1.27	11.8	0.9	0.9	8.6	19	16
9/26/79	99.0	59.4	9.5	3.2	0.72	8.6	0.99	13.4	2.4	0.5	9.1	19	16
10/3/79	180	128.7	7.2	3.8	0.54	10.0	0.53	22.4	0.9	0.8	12.0	18	15

TABLE A-12. ANALYSIS RESULTS BASIN 2 (YEAR 2) - PRIMARY EFFLUENT APPLICATION

Loading date	Alkalinity (mg/ℓ)		Chloride (mg/ℓ)		Hardness (mg/ℓ)		Calcium (mg/ℓ)		Magnesium (mg/ℓ)		SS (mg/ℓ)		Tot. sol. (mg/ℓ)	
	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF
11/15/78	194	132	26	31	204	224	65	65	10	15	48	1.8	508	420
11/22/78	216	145	29	32	177	213	59	65	7	12	41.0	2.5	440	294
11/29/78	-	120	-	30	-	202	-	62	-	12	-	6.6	-	508
1/24/79	185	114	26.5	27.7	197	243	54	63	15	21	35.5	1.8	393	423
1/31/79	196	142	26.7	29.6	194	212	57.7	63.4	12	13	66	2.1	441	403
2/7/79	188	168	30.1	34.2	226	221	68.1	65.6	13.6	13.9	99	12.5	464	396
2/14/79	158	162	27.7	32.3	168	237	51	74	10	13	31.5	0.7	409	463
2/21/79	183	-	30.4	-	203	-	61	-	12	-	50	-	470	-
2/28/79	168	152	29.5	30.6	170	227	47.5	67.0	26	14	37.5	3.9	390	387
4/4/79	203	116	28.9	31.4	264	266	78	83	17	15	71	0.8	529	517
4/11/79	182	123	28	30	221	250	64	71	15	17	84	0.9	456	458
4/18/79	181	132	30	30	234	252	70	73	14	17	52	1.1	441	428
4/25/79	168	134	31	31	228	228	64.8	75.2	16	10	41	1.0	420	408
5/2/79	169	138	29	29	240	230	65	71	19	13	25	1.3	432	409
5/9/79	229	146	29	28	342	352	108	75	18	16	43	1	538	430
5/23/79	184	148	30	28	285	285	83	81	19	20	42	0.7	501	-
5/30/79	183	157	29.0	35.5	264	306	73.6	82.1	19.4	24.5	47.5	0.6	453	508
6/6/79	193	162	35.4	35.4	311	308	80.2	81.1	27.0	25.8	33.5	0.8	491	493
6/13/79	187	147	32.1	32.8	312	283	83.6	80.8	25.0	19.7	51.5	2.4	496	438
6/20/79	208	148	26.4	26.4	326	264	110	98.1	12.4	4.6	36.0	0.8	505	444
6/27/79	185	165	24.0	30.9	273	314	72.1	84.6	22.6	25.0	72.0	0.7	489	509
7/11/79	162	137	22.2	26.9	254	281	63.5	76.0	23.3	22.1	28.0	2.1	437	497
7/18/79	177	142	22.9	26.7	266	266	69.2	73.1	22.6	20.4	47.0	0.4	476	498
7/25/79	173	140	20.3	24.6	259	281	82.7	76.9	12.9	21.6	30.5	0.3	428	474
8/1/79	168	148	22.9	26.7	254	266	63.5	73.1	23.3	23.4	43.0	1.0	402	416
8/8/79	166	161	21.5	28.3	259	298	64.7	88.2	23.8	19.0	18.0	0.4	415	511
8/15/79	176	157	31.1	31.1	284	286	73.5	81.4	24.5	20.2	17.5	0.4	449	503

(continued)

TABLE A-12 (continued)

Loading date	Alkalinity (mg/ℓ)		Chloride (mg/ℓ)		Hardness (mg/ℓ)		Calcium (mg/ℓ)		Magnesium (mg/ℓ)		SS (mg/ℓ)		Tot. sol. (mg/ℓ)	
	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF
8/29/79	167	154	21.9	29.0	250	293	69.3	86.6	18.7	18.7	24	0.9	446	505
9/5/79	215	145	21.0	24.8	273	252	82.7	84.6	16.3	10.0	62.0	1.6	553	441
9/12/79	183	160	20.5	24.1	214	224	62.5	69.7	14.1	12.2	28.0	0.3	457	476
9/19/79	171	145	21.5	24.3	198	215	52.2	65.1	15.6	12.9	29.5	0.7	546	412
9/26/79	184	155	18.9	26.2	212	224	60.5	70.3	14.8	11.7	26.0	0.5	405	417
10/3/79	229	167	20.1	26.4	229	226	78.9	73.6	7.8	10.4	35.5	0.5	514	461

TABLE A-13. ANALYSIS RESULTS BASIN 3 (YEAR 1) - SECONDARY EFFLUENT APPLICATION

Loading date	COD (mg/ℓ) Total INF	COD (mg/ℓ) Soluble INF	COD (mg/ℓ) Total EFF	Total PO_4-P (mg/ℓ) INF	Total PO_4-P (mg/ℓ) EFF	Aver. NH_4^+-N (mg/ℓ) INF	Aver. NH_4^+-N (mg/ℓ) EFF	TKN (mg/ℓ) INF	TKN (mg/ℓ) EFF	Aver. NO_3^--N (mg/ℓ) INF	Aver. NO_3^--N (mg/ℓ) EFF	Temperature (°C) minimum INF	Temperature (°C) minimum EFF
7/14/76	59.0	-	17.7	5.4	0.12	6.0	1.2	-	-	1.15	1.9	20	16
7/21/76	48.1	-	12.1	4.0	0.13	6.0	-	9.5	-	1.82	-	-	18
7/28/76	52.6	-	16.6	4.8	0.10	-	-	-	-	2.7	0.05	20	18
8/25/76	51.0	-	16.8	5.6	0.12	2.2	0.87	-	0	2.0	2.8	-	17
9/1/76	62.2	-	14.0	4.4	0.08	8.0	0.79	12.8	-	1.36	0.22	20	18
9/8/76	57.7	-	16.9	6.4	0.12	9.9	0.58	12.5	-	1.94	0.14	19	18
9/15/76	56.2	-	18.4	5.8	0.40	4.8	0.71	12.3	0	1.90	0.71	19	18
10/13/76	62.0	-	15.5	3.0	0.12	2.51	0.5	12.7	-	5.24	2.0	18	15
10/20/76	64.5	-	15.5	8.0	0.05	1.3	0.15	11.6	-	4.4	1.6	14.5	13
10/27/76	66.1	-	15.5	6.0	0.08	3.75	0.22	11.9	-	2.5	0.5	13.5	12
12/1/76	86.4	55.4	19.6	6.0	0.09	8.4	0.57	10.3	-	1.2	3.7	10	9.5
2/10/77	102	56.9	36.7	6.0	0.18	3.1	0.18	23.9	3.1	0	0.10	9	5
2/17/77	112	70.0	47.4	7.5	1.39	8.0	2.15	23.5	7.5	2.2	0.90	9	6
2/24/77	113	53.6	28.9	7.0	0.73	12.5	2.3	22.1	5.24	0.71	0.90	-	7
4/14/77	75.4	32.4	18.6	3.0	0.30	11.0	2.78	-	3.6	1.92	21.9	12	9
4/21/77	49.6	29.8	19.6	2.0	0.75	4.6	1.38	12.3	4.8	1.6	2.56	12	8
5/12/77	54.9	47.2	18.5	6.67	0.15	5.6	0.33	15.8	2.4	1.3	12.4	15	12
5/19/77	70.8	37.8	-	5.25	0.80	6.89	0.43	22.3	3.6	1.4	8.3	17	13
6/2/77	76.7	48.0	18.8	5.5	0.50	7.03	1.61	11.5	1.90	2.1	15.4	17	14
6/9/77	62.8	28.3	25.3	4.67	0.96	4.9	0.94	10.8	2.74	2.8	4.4	18	15
6/16/77	56.7	25.1	16.2	5.4	1.65	5.6	1.39	8.0	1.97	1.6	5.1	18	15.5
6/23/77	59.6	29.1	19.5	5.0	1.63	5.43	1.20	9.3	2.13	1.6	4.0	19	16

(continued)

TABLE A-13 (continued)

Loading date	COD (mg/ℓ) Total INF	COD (mg/ℓ) Soluble INF	COD (mg/ℓ) Total EFF	Total PO_4-P (mg/ℓ) INF	Total PO_4-P (mg/ℓ) EFF	Aver. NH_4^+-N (mg/ℓ) INF	Aver. NH_4^+-N (mg/ℓ) EFF	TKN (mg/ℓ) INF	TKN (mg/ℓ) EFF	Aver. NO_3^--N (mg/ℓ) INF	Aver. NO_3^--N (mg/ℓ) EFF	Temperature (°C) minimum INF	Temperature (°C) minimum EFF
6/30/77	54.2	21.8	13.6	4.83	1.75	5.0	1.68	8.5	2.05	2.3	4.7	18	16
7/7/77	60.8	27.6	14.8	5.40	1.68	5.9	1.14	11.5	2.43	2.1	2.2	19	18
8/4/77	56.5	25.5	17.0	3.83	0.79	5.7	0.87	10.5	1.9	2.8	9.4	20	17
8/11/77	52.8	28.3	16.2	4.0	0.50	6.9	1.11	7.3	0	3.4	6.5	19	18
8/18/77	54.0	26.6	13.3	3.50	0.90	6.6	0.90	9.4	1.0	3.2	5.6	-	19
8/25/77	61.6	31.7	15.7	4.50	1.20	6.2	0.71	6.5	0.	3.5	6.0	20	18

TABLE A-14. ANALYSIS RESULTS BASIN 3 (YEAR 1) - SECONDARY EFFLUENT APPLICATION

Loading date	Alkalinity (mg/ℓ)		Chloride (mg/ℓ)		Hardness (mg/ℓ)		Calcium (mg/ℓ)		Magnesium (mg/ℓ)		SS (mg/ℓ)		Tot. sol. (mg/ℓ)	
	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF
7/14/76	130	217	25.0	32.0	155	249	-	-	-	-	12.4	1.2	349	487
7/21/76	122	192	22.0	25.5	163	211	-	-	-	-	9.2	0.8	355	443
7/28/76	134	202	30.0	25.0	162	216	-	-	-	-	24.0	0.8	364	399
8/25/76	126	216	32.0	27.5	146	250	-	-	-	-	18.2	0	350	426
9/1/76	119	202	33.5	28.5	150	232	-	-	-	-	12.2	0	328	416
9/8/76	129	185	33.0	29.0	142	208	-	-	-	-	15.2	0	342	366
9/15/76	135	186	36.5	30.0	140	204	-	-	-	-	17.0	0	385	395
10/13/76	118	188	33	29	126	246	-	-	-	-	29	14	341	396
10/20/76	116	182	42.5	31.0	118	224	-	-	-	-	18	3	337	385
10/27/76	130	171	34.5	33.5	122	190	-	-	-	-	18	0.4	276	315
12/1/76	118	160	43.5	35.0	100	218	-	-	-	-	21	0.4	385	480
2/10/77	163	166	22.0	29.0	100	208	-	-	-	-	15.5	0.2	262	358
2/17/77	164	152	27.5	31.5	100	176	36	69	3	3	24.0	0.2	273	302
2/24/77	155	168	26.0	28.5	96	173	-	-	-	-	26.5	0	244	266
4/14/77	107	108	30.5	31.5	106	218	24.0	48.0	11.0	23.0	21.5	0	341	481
4/21/77	118	136	28.0	28.0	140	220	32.0	48.0	14.5	24.0	20.5	0	339	376
5/12/77	148	122	27.5	32.0	126	228	35.3	58.5	9.1	19.6	17.5	0.4	327	447
5/19/77	153	128	25.0	26.5	130	164	26.5	46.4	15.3	11.5	20.0	0	305	335
6/2/77	146	117	28.0	27.5	131	176	34.1	55.6	11.0	8.6	9.0	0	332	382
6/9/77	132	118	26.0	26.0	144	153	31.1	40.0	16.1	12.9	15.5	0	363	365
6/16/77	146	112	26.5	27.0	137	146	44.5	38.6	6.3	12.1	14.0	0	305	308
6/23/77	133	109	23.5	28.5	136	158	32.1	38.5	13.6	15.0	11.0	0	311	295
6/30/77	141	122	23.0	23.5	140	150	28.1	36.1	17.0	14.5	24.0	0	312	-
7/7/77	135	129	25.0	25.0	134	129	28.1	38.5	15.5	14.0	11.0	0	308	301

(continued)

TABLE A-14 (continued)

Loading date	Alkalinity (mg/ℓ)		Chloride (mg/ℓ)		Hardness (mg/ℓ)		Calcium (mg/ℓ)		Magnesium (mg/ℓ)		SS (mg/ℓ)		Tot. sol. (mg/ℓ)	
	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF
8/4/77	140	125	24.0	24.0	160	176	32.9	44.1	18.7	15.8	10.0	0	234	352
8/11/77	126	106	25.5	27.5	156	158	40.1	44.1	13.4	11.5	17.0	0	373	382
8/18/77	132	117	24.0	24.0	158	146	41.0	40.0	13.3	11.1	18.5	0	369	353
8/25/77	120	107	24.0	23.5	136	140	30.0	36.1	8.8	11.9	9.6	0	286	265

TABLE A-15. ANALYSIS RESULTS BASIN 3 (YEAR 2) - SECONDARY EFFLUENT APPLICATION

Loading date	COD (mg/ℓ) Total INF	COD (mg/ℓ) Soluble INF	COD (mg/ℓ) Total EFF	Total PO_4-P (mg/ℓ) INF	Total PO_4-P (mg/ℓ) EFF	Aver. NH_4^+-N (mg/ℓ) INF	Aver. NH_4^+-N (mg/ℓ) EFF	TKN (mg/ℓ) INF	TKN (mg/ℓ) EFF	Aver. NO_3^--N (mg/ℓ) INF	Aver. NO_3^--N (mg/ℓ) EFF	Temperature (°C) minimum INF	Temperature (°C) minimum EFF
9/8/77	69.0	55.2	12.2	7.0	0.69	7.33	0.68	2.51	1.55	2.2	8.4	21	18
9/15/77	65.0	55.8	23.8	6.7	1.5	8.47	0.67	17.0	2.61	3.1	7.8	19	18
9/22/77	71.7	47.9	23.0	7.1	2.1	5.50	0.37	20.0	1.75	3.8	7.9	18	16
9/29/77	68.3	50.2	17.3	6.7	2.3	5.75	0.82	24.1	1.62	4.2	7.7	19	16
10/6/77	70.6	56.2	21.4	6.7	2.6	8.38	0.99	6.23	1.95	5.1	7.8	17	15
11/2/77	83.5	56.7	10.4	7.3	0.7	8.32	0.41	10.3	-	4.8	11.9	15	13
11/10/77	85.0	48.8	20.0	6.8	2.8	7.59	0.69	10.0	1.06	4.9	9.5	12	12
11/17/77	82.0	52.8	29.6	7.3	3.6	9.54	0.94	11.2	3.16	4.8	8.8	13	10.5
11/24/77	82.0	55.2	23.4	7.2	3.8	9.08	1.30	23.6	1.46	2.9	7.6	12	9
12/1/77	77.2	49.2	19.0	7.0	3.9	8.78	1.66	16.1	3.36	5.2	7.8	10	8
12/8/77	88.0	54.0	22.8	6.7	3.8	8.46	2.14	10.5	3.73	4.2	5.4	10	7
12/15/77	92.0	55.6	22.0	8.0	2.5	10.4	3.07	15.4	3.08	3.9	4.0	13	7
1/19/78	77.6	37.0	20.2	7.2	4.1	12.4	2.34	11.1	2.30	< 1	4.6	10	4
2/2/78	42	30	11	5.7	4.5	16.0	3.11	20.2	1.21	2.8	8.2	8	3.5
2/9/78	59	39	22	6.6	4.4	6.6	4.3	9.3	2.3	2.6	6.4	10	4.5
2/16/78	70	50	25	8.4	4.6	12.5	3.7	10.6	-	2.0	4.4	9	3
2/22/78	77	45	21	9.1	4.5	14.5	3.7	-	-	1.7	4.2	8	5
3/23/78	90.6	48.8	25.3	8.2	3.0	13.5	2.8	-	-	2.7	32.2	11	7
3/30/78	67.7	56.6	14.4	7.1	4.6	8.70	2.1	-	-	2.6	5.4	14	9
4/13/78	83.3	78.3	23.8	5.9	4.2	5.15	3.7	-	-	4.5	2.6	13	10
4/20/78	87.6	61.2	21.2	6.3	3.9	10.6	1.95	-	-	5.5	4.7	13	10
4/27/78	70.3	54.9	22.1	6.4	3.0	12.1	2.4	-	-	2.0	0.55	14.5	10.5
6/15/78	52.4	33.5	16.5	3.2	1.06	7.1	8.6	-	-	2.6	14.4	-	13
6/22/78	62.6	26.0	18	3.4	1.20	8.3	5.1	-	-	2.1	5.4	-	16
6/29/78	58.2	35.4	18.4	3.4	1.7	8.0	4.3	-	-	1.9	3.8	18	15

TABLE A-16. ANALYSIS RESULTS BASIN 3 (YEAR 2) - SECONDARY EFFLEUNT APPLICATION

Loading date	Alkalinity (mg/ℓ)		Chloride (mg/ℓ)		Hardness (mg/ℓ)		Calcium (mg/ℓ)		Magnesium (mg/ℓ)		SS (mg/ℓ)		Tot. sol. (mg/ℓ)	
	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF
9/8/77	129	116	26.0	22.5	124	152	38.4	44.0	6.7	10.1	17.8	0.0	313	333
9/15/77	129	112	27	27	122	148	44.8	48.0	2.4	6.7	11.2	0.0	292	294
9/22/77	126	109	25	23.5	126	140	36.8	40.0	8.2	9.6	13.2	0.0	317	312
9/29/77	132	109	24	23.5	134	136	39.2	41.6	8.6	7.7	20.1	0.0	321	306
10/6/77	118	102	27.5	26.0	116	132	32	36.8	8.6	10.1	13.5	0.0	315	308
11/3/77	113	116	27	23	108	128	29.6	41.6	8.2	5.8	15.0	0.0	295	335
11/10/77	112	-	24	25.5	104	116	28	32	8.2	8.6	15.5	4.0	273	306
11/17/77	115	94	24	23	96	128	28.8	45.6	5.8	3.4	19.8	7.8	311	300
11/24/77	116	88	27	21.5	94	104	26.4	31.2	6.7	6.2	19.0	5	296	267
12/1/77	59	99	14.5	28.0	94	114	19.2	26.4	11.0	11.5	16.0	0.8	303	296
12/8/77	121	104	28.5	29.0	94	120	30.4	40.9	4.4	4.4	17.5	0	356	191
12/15/77	121	117	25.5	31	100	124	40	48.8	0	0.5	1.3	0.8	390	295
1/19/78	53	88	15	35	62	130	19.2	39.2	3.4	7.8	12	4	-	-
2/2/78	100	131	-	-	92	120	28	28	5.4	12.2	5	2	160	159
2/9/78	134	110	27	30	84	106	25	26	5.4	10.2	34	15	318	295
2/16/78	140	116	28	26	82	106	28	29	2.9	8.3	22	9	316	295
2/22/78	174	139	27	27	90	120	26	30	5.9	10.7	13	1	315	308
3/23/78	158	100	27	27	94	136	30	36	4.9	4.2	13	1	315	308
3/30/78	142	110	26	31	110	144	32.1	36.9	7.3	12.7	12	0	327	321
4/13/78	137	120	25	26	124	130	37	35	7.8	10.7	15	1	373	348
4/20/78	129	121	27	27	114	142	38	37	4.4	12.2	18	1	425	308
4/27/78	136	141	23	26	104	146	38	37	2.4	13.2	8	0	314	322
6/15/78	123	94	23	25	150	189	42	49	8.3	16.3	22	5	250	325
6/22/78	156	125	22	28	186	186	45	51	17.1	14	6	4	349	326
6/29/78	155	119	24	24	179	159	42	41	18	13.7	7	8	320	308

TABLE A-17. ANALYSIS RESULTS BASIN 3 (YEAR 3) - PRIMARY EFFLUENT APPLICATION

Loading date	COD (mg/ℓ) Total INF	COD (mg/ℓ) Soluble INF	COD (mg/ℓ) Total EFF	Total PO_4-P (mg/ℓ) INF	Total PO_4-P (mg/ℓ) EFF	Aver. NH_4-N (mg/ℓ) INF	Aver. NH_4-N (mg/ℓ) EFF	TKN (mg/ℓ) INF	TKN (mg/ℓ) EFF	Aver. NO_3-N (mg/ℓ) INF	Aver. NO_3-N (mg/ℓ) EFF	Temperature (°C) minimum INF	Temperature (°C) minimum EFF
11/16/78	109	67	16.3	5.0	0.44	11.0	0.19	-	0.48	0.2	3.8	13	12
11/30/78	157	70	12	4.8	0.27	15.6	-	9.2	-	0.2	-	12	10
2/15/79	157	73.7	20.4	7.1	0.32	7.5	0.64	16.1	1.2	0.5	5.6	10	5
2/22/79	-	-	23.0	-	0.39	-	-	-	1.30	-	-	-	6
2/29/79	263	138	19.9	6.8	0.48	23.0	1.2	29.0	1.57	0.0	4.1	9	6
4/5/79	124	34	17.1	6.3	0.38	11.0	0.95	19.7	1.0	0.1	28.7	10	7
4/12/79	112	31	16	2.5	0.73	6.5	0.78	12.0	2.2	0.1	9.2	11	7
4/19/79	119	59	16	2.3	0.59	6.3	0.76	11.0	2.2	0.3	14.1	12	9
4/26/79	96	39	11	2.5	0.56	6.2	0.44	13.1	1.3	0.3	11.2	13	10
5/3/79	81	28	15	1.5	0.78	4.5	0.55	10.2	1.09	2.0	8.7	10	10
5/24/79	116	42	12	2.4	0.52	6.8	0.70	12.0	0.48	2.0	11.9	14.5	12
5/31/79	94.4	32.7	11.9	1.6	0.57	4.8	0.54	10.6	0.94	3.6	9.0	12	11
6/14/79	148.4	68.7	10.9	2.3	0.49	6.6	0.62	14.8	0.82	2.8	8.9	17	13
6/21/79	96.3	34.7	9.4	2.2	0.53	4.6	0.38	9.7	0.60	2.6	5.2	17	13
6/28/79	106.1	41.2	11.2	1.9	0.57	5.2	0.32	9.8	1.1	1.0	5.1	18	14
7/12/79	64.9	23.9	9.5	1.8	0.46	4.1	0.23	7.7	0.36	1.6	5.8	19	15
7/19/79	74.4	36.6	10.3	2.0	0.45	4.5	0.23	8.7	0.73	1.5	11.9	18	14.5
7/26/79	61.4	24.7	11.1	2.5	0.50	5.6	0.42	7.6	0.9	1.5	10.7	15.5	16
8/2/79	68.4	22.5	11.2	2.0	0.47	4.7	0.37	7.6	0.0	1.9	9.5	19	15.5
8/9/79	56.6	23.7	9.8	1.3	0.58	4.1	0.20	7.0	0.60	2.1	7.4	19	16
8/16/79	103.2	55.1	12.6	1.9	0.71	4.7	0.23	11.3	0.84	2.3	5.6	19.5	17
8/30/79	87.4	31.3	10.6	2.6	0.62	10.0	0.33	12.5	0.6	1.0	9.4	19.5	16
9/6/79	69.5	37.8	9.1	2.8	0.66	7.0	0.37	9.0	2.2	0.7	8.6	20	17
9/13/79	162.4	82.2	11.4	3.6	0.99	9.0	0.54	17.7	1.1	0.7	7.8	19	17
9/20/79	98.4	42.7	14.3	3.1	1.02	9.6	0.79	12.5	1.0	0.4	7.3	19	17
9/27/79	84.9	33.6	9.5	3.1	1.07	8.13	0.90	11.8	0.2	0.4	6.1	18	16.5
10/4/79	93.3	40.5	11.0	3.4	1.34	9.32	0.73	13.9	1.1	0.5	6.0	17	15.5

TABLE A-18. ANALYSIS RESULTS BASIN 3 (YEAR 3) - PRIMARY EFFLUENT APPLICATION

Loading date	Alkalinity (mg/ℓ)		Chloride (mg/ℓ)		Hardness (mg/ℓ)		Calcium (mg/ℓ)		Magnesium (mg/ℓ)		SS (mg/ℓ)		Tot. sol. (mg/ℓ)	
	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF
11/16/78	163	94	25	20	181	238	57	72	9	14	44	10	370	165
11/30/78	167	116	30	29	147	224	53	69	4	12	60	5.6	478	580
2/15/79	158	97	29.9	27.4	178	227	45	62	16	17	42.5	5.8	431	420
2/22/79	-	112	-	29.2	-	240	-	65	-	19	-	1.0	-	415
2/29/79	213	212	28.9	28.4	173	227	51	62	11	17	54.5	2.8	434	396
4/5/79	162	96	30	29	178	281	52	79	12	20	53	0.6	451	519
4/12/79	191	97	30	30	264	221	82	70	15	11	63	1.5	485	412
4/19/79	182	108	32	31	259	238	78	70	16	16	39	0.7	438	419
4/26/79	192	116	29	32	266	238	91	70	11	16	40	1.1	446	432
5/3/79	180	121	27	29	264	226	74	62	19	18	34	0.8	445	401
5/24/79	190	129	26	32	282	301	81	78	19	26	50	0.9	-	521
5/31/79	191	128	27.4	31.6	285	282	76.4	76.4	22.8	22.1	42.5	0.9	466	470
6/14/79	217	139	29.3	39.4	307	312	90.4	83.6	19.7	25.0	57.0	2.4	524	488
6/21/79	218	137	25.3	30.4	341	288	127	92.3	5.8	14.1	50.5	0.1	511	478
6/28/79	178	141	24.8	29.5	276	273	68.3	72.1	25.8	22.6	52.0	0.4	458	456
7/12/79	160	137	21.2	27.8	259	278	65.4	71.2	23.3	24.3	37.5	1.2	435	477
7/19/79	178	134	23.4	28.1	271	273	71.2	72.1	22.6	22.6	29.5	0.2	481	495
7/26/79	163	126	20.8	24.3	257	271	85.6	72.1	10.4	22.1	23.0	0.3	428	456
8/2/79	176	130	22.9	25.2	264	257	68.3	67.3	22.8	21.6	23.0	0.9	376	388
8/9/79	169	127	23.6	25.0	259	245	66.7	64.7	22.6	20.4	21.0	0.2	452	439
8/16/79	211	145	22.4	22.6	284	249	76.5	64.7	22.6	21.4	27.5	0.2	469	430
8/30/79	172	129	23.6	23.8	228	247	57.7	67.3	20.4	19.2	32.0	1.1	413	441
9/6/79	165	129	20.5	23.1	240	240	71.2	68.3	15.1	17.0	28.0	1.1	439	420
9/13/79	191	138	21.9	21.9	214	200	63.6	58.5	13.4	13.1	49.0	1.0	482	397

(continued)

TABLE A-18 (continued)

Loading date	Alkalinity (mg/ℓ)		Chloride (mg/ℓ)		Hardness (mg/ℓ)		Calcium (mg/ℓ)		Magnesium (mg/ℓ)		SS (mg/ℓ)		Tot. sol. (mg/ℓ)	
	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF	INF	EFF
9/20/79	168	132	20.3	21.9	194	194	51.4	53.8	16.0	14.6	32.5	0.6	394	380
9/27/79	162	134	20.1	21.2	188	196	49.1	55.6	16.0	13.9	26.5	0.6	374	365
10/4/79	167	137	23.4	22.7	170	173	56.1	58.7	7.3	6.6	25.0	0.7	382	360

TABLE A-19. CYCLE AVERAGES - BASIN 1 (YEAR 1) - SECONDARY EFFLUENT APPLICATION

	Beginning Date of Loading Cycle								
	7/12/76	8/24/76	10/11/76	11/29/76	2/8/77	4/12/77	5/10/77	5/31/77	7/19/77
Inf COD (Total)	55.1	58.2	64.5	83.4	135	43.3	76.8	58.2	60.0
Inf COD (Sol)	—	—	—	50.9	75.1	28.5	56.2	31.2	30.9
Eff COD	12.0	11.7	10.8	17.7	26.9	12.3	19.4	12.1	12.1
% Rem Total COD	78.0	80	83	79	79	69	75	79	80
% Rem Sol COD	—	—	—	65.2	64.2	56.8	65.5	61.2	60.8
Eff Total PO_4-P	0.18	0.61	0.93	1.41	1.71	0.85	0.92	0.81	0.68
% Rem Total PO_4-P	96	90	88	82	77	—	85	78	84
Ave Eff NH_4^+-N	0.39	0.37	0.35	0.78	0.98	0.44	0.12	0.26	0.30
Ave Eff NO_3^--N	7.9	7.2	10.8	9.5	9.9	23.2	21.6	10.2	10.3
Eff Ca^{++}	—	—	—	—	53.9	86.5	77.0	65.6	68.4
Delta Ca^{++}	—	—	—	—	+ 21.6	+ 51.5	+ 42.5	+ 30.3	+ 29.6
Eff Hardness	246	228	202	191	216	315	274	235	256
Delta Hardness	+ 82	+ 71	+ 73	+ 68	+105	+204	+143	+883	+ 87
Eff Alkalinity	192	182	154	138	167	182	164	171	166
Delta Alkalinity	+ 54	+ 47	+ 25	- 6	- 3	+ 94	+ 14	+ 23	+ 26
Eff Cl^-	30.5	30.9	30.7	30.4	31.1	33.5	33.2	30.8	29.5
Delta Cl^-	+ 5.5	+ 5.5	+ 4.1	+ 1.8	+ 2.8	+ 5.0	+ 4.5	+ 5.8	+ 5.4
SS	13.6	15.0	22.1	26.7	29.2	13.8	15.8	12.0	9.2

TABLE A-20. CYCLE AVERAGES - BASIN 1 (YEAR 2) - SECONDARY EFFLUENT APPLICATION

	Beginning Date of Loading Cycle				
	9/6/77	11/1/77	1/10/78	3/21/78	6/13/78
Inf COD (Total)	70.7	80.1	76.3	77.7	56.5
Inf COD (Sol)	52.8	54.2	47.7	51.7	34.6
Eff COD	11.9	14.2	14.8	15.9	16.8
% Rem Total COD	83.2	82.3	80.6	79.5	70.3
% Rem Sol COD	77.5	73.8	70.0	69.2	51.4
Eff Total PO_4-P	0.91	1.62	2.54	3.38	0.85
% Rem Total PO_4-P	86.4	76.9	62.6	49.1	77.0
Ave Eff NH_4^+-N	0.16	0.23	0.94	0.65	0.27
Ave Eff NO_3^--N	12.3	14.2	12.4	12.2	11.5
Eff Ca^{++}	71.9	68.8	56.0	59.5	78.0
Delta Ca^{++}	+ 28.9	+ 40.1	+ 34.2	+ 27.6	+ 31.0
Eff Hardness	253	221	180	208	284
Delta Hardness	+124	+115	+100	+ 91	+117
Eff Alkalinity	131	123	156	151	129
Delta Alkalinity	+ 37.6	+ 31.6	- 24.8	- 6.2	+ 19.0
Eff Cl^-	30.4	29.3	32.4	28.1	29.5
Delta Cl^-	+ 5.8	+ 0.7	+ 0.7	- 0.6	+ 5.5
SS	14.8	14.8	28.2	21.2	9.7

TABLE A-21. CYCLE AVERAGES - BASIN 1 (YEAR 3) - PRIMARY EFFLUENT APPLICATION

	Beginning Date of Loading Cycle					
	11/7/78	1/23/79	4/3/79	5/22/79	7/10/79	8/28/79
Inf COD (Total)	239	174	94.2	102	88.5	86.3
Inf COD (Sol)	164	77.8	34.8	48.9	31.3	36.5
Eff COD	15.4	19.5	8.6	9.8	10.6	9.8
% Rem Total COD	93.2	88.8	90.1	89.1	84.3	86.3
% Rem Sol COD	89.9	72.6	72.3	71.9	65.3	65.0
Eff Total PO_4-P	0.39	0.55	0.53	0.55	0.53	0.55
% Rem Total PO_4-P	92.7	90.8	79.6	71.0	77.9	80.6
Ave Eff NH_4^+-N	0.16	0.80	0.78	0.08	0.05	0.13
Ave Eff NO_3^--N	17.6	4.6	20.2	9.9	11.4	9.9
Eff Ca^{++}	128	92.7	112	108	110	102
Delta Ca^{++}	+62.8	+39.2	+44.0	+29.7	+42.5	+42.5
Eff Hardness	380	323	383	389	402	353
Delta Hardness	+193	+140	+137	+94.6	+141	+136
Eff Alkalinity	171	188	179	197	206	211
Delta Alkalinity	- 2.3	- 2.7	- 1.8	- 0.8	+18.3	+34.8
Eff Cl^-	37.4	33.1	33.5	32.8	30.9	28.6
Delta Cl^-	+8.9	+2.6	+5.2	+4.2	+8.4	+7.8
SS	75.0	71.0	34.0	53.2	43.8	27.9

TABLE A-22. CYCLE AVERAGES - BASIN 2 (YEAR 1) - SECONDARY EFFLUENT APPLICATION

	Beginning Date of Loading Cycle						
	7/12/76	8/24/76	10/11/76	11/29/76	4/12/77	5/31/77	7/19/77
Inf COD (Total)	56.8	63.2	71.2	86.6	50.9	57.8	58.0
Inf COD (Sol)	—	—	—	52.2	30.4	32.5	28.8
Eff COD	15.8	14.2	14.9	22.4	8.8	9.1	7.8
% Rem Total COD	72	78	78	74	82	84	87
% Rem Sol COD	—	—	—	57.1	71.0	72.0	72.9
Eff Total PO_4-P	0.15	0.11	0.22	0.30	0.23	0.12	0.07
% Rem Total PO_4-P	94	99	97	96	85	98	98
Ave Eff NH_4^+-N	—	0.23	0.45	0.18	0.19	0.10	0.27
Ave Eff NO_3^--N	1.7	1.1	2.4	9.7	8.8	8.9	6.0
Eff Ca^{++}	—	—	—	—	74.4	60.2	54.6
Delta Ca^{++}	—	—	—	—	+ 40.6	+ 24.9	+ 16.5
Eff Hardness	256	242	224	236	283	225	212
Delta Hardness	+ 93	+ 92	+109	+138	+156	+ 88	+ 53
Eff Alkalinity	202	206	197	185	170	152	158
Delta Alkalinity	+ 75	+ 64	+ 83	+ 68	+ 62	+ 17	+ 23
Eff Cl^-	35.9	37.0	35.4	36.5	35.4	31.2	28.3
Delta Cl^-	+ 9.1	+ 3.6	+ 1.0	+ 2.0	+ 8.4	+ 6.5	+ 4.6
SS	14.3	15.8	21.0	23.0	15.4	10.6	9.9

TABLE A-23. CYCLE AVERAGES - BASIN 2 (YEAR 2) - SECONDARY EFFLUENT APPLICATION

	Beginning Date of Loading Cycle				
	9/6/77	11/1/77	1/10/78	3/21/78	6/13/78
Inf COD (Total)	69.8	83.6	67.2	74.7	53.7
Inf COD (Sol)	53.3	53.0	39.4	53.6	33.5
Eff COD	11.2	12.8	14.7	11.8	12.2
% Rem Total COD	84.0	84.7	78.1	84.2	77.3
% Rem Sol COD	79.0	75.8	62.7	78.0	63.6
Eff Total PO_4-P	0.14	0.35	1.0	1.4	0.66
% Rem Total PO_4-P	97.9	95.0	85.5	79.8	85.2
Ave Eff NH_4^+-N	0.15	0.23	1.20	0.35	0.51
Ave Eff NO_3^--N	10.5	13.4	11.8	15.9	11.2
Eff Ca^{++}	60.8	56.8	36.4	43.8	48.8
Delta Ca^{++}	+ 20.8	+ 29.1	+ 7.4	+ 8.8	+ 0.2
Eff Hardness	214	184	146	161	175
Delta Hardness	+ 85.6	+ 88.0	+ 48.8	+ 52.5	+ 3.3
Eff Alkalinity	152	124	96.2	105	110
Delta Alkalinity	+ 17.8	+ 6.7	- 42.6	- 53.0	- 28.0
Eff Cl^-	27.7	28.8	25.0	26.9	25.7
Delta Cl^-	+ 3.5	+ 3.6	+ 1.3	+ 0.5	+ 3.5
SS	17.0	15.7	22.0	17.2	8.3

TABLE A-24. CYCLE AVERAGES - BASIN 2 (YEAR 3) - PRIMARY EFFLUENT APPLICATION

	Beginning Date of Loading Cycle					
	11/7/78	1/23/79	4/3/79	5/22/79	7/10/79	8/28/79
Inf COD (Total)	223	176	126	99.5	73.7	113
Inf COD (Sol)	163	68.7	51.9	38.3	26.6	—
Eff COD	21.0	25.0	16.8	11.3	12.2	11.8
% Rem Total COD	90.4	85.7	85.6	88.1	82.7	87.7
% Rem Sol COD	86.8	62.6	64.3	68.0	52.1	—
Eff Total PO_4-P	0.71	0.79	0.94	0.62	0.61	0.70
% Rem Total PO_4-P	86.3	83.2	62.4	65.5	68.5	76.1
Ave Eff NH_4^+-N	0.51	2.4	0.89	0.49	0.50	0.73
Ave Eff NO_3^--N	—	3.1	14.0	10.0	11.7	10.2
Eff Ca^{++}	64.0	66.6	74.7	84.6	78.1	74.9
Delta Ca^{++}	+ 3.0	+ 11.0	- 0.3	+ 0.9	+ 8.6	+ 7.3
Eff Hardness	213	228	246	293	280	239
Delta Hardness	+ 28.0	+ 36.8	- 8.5	- 1.8	+ 18.7	+ 9.8
Eff Alkalinity	132	148	132	154	148	154
Delta Alkalinity	- 68.0	- 31.4	- 57.2	- 34.3	- 22.8	- 37.2
Eff Cl^-	31.0	30.9	29.9	31.5	25.7	25.8
Delta Cl^-	+ 4.0	+ 2.8	+ 0.5	+ 2.0	+ 3.9	+ 5.2
SS	44.5	53.2	52.6	47.0	30.6	34.2

TABLE A-25. CYCLE AVERAGES - BASIN 3 (YEAR 1) - SECONDARY EFFLUENT APPLICATION

	Beginning Date of Loading Cycle								
	7/12/76	8/24/76	10/11/76	11/29/76	2/8/77	4/12/77	5/10/77	5/31/77	7/19/77
Inf COD (Total)	53.2	56.8	64.2	86.4	109	62.5	62.8	61.8	56.2
Inf COD (Sol)	—	—	—	55.4	60.2	31.1	42.5	30.0	28.0
Eff COD	15.5	16.5	15.5	19.6	37.7	19.1	18.5	18.0	15.5
% Rem Total COD	71	71	76	78	62	68	66	72	72
% Rem Sol COD	—	—	—	64.6	37.4	38.5	56.5	40.0	44.6
Eff Total PO_4-P	0.12	0.18	0.09	0.09	0.77	0.53	0.48	1.25	0.85
% Rem Total PO_4-P	98	97	98	98	89	76	92	75	78
Ave Eff NH_4^+-N	—	0.74	0.30	0.57	1.4	2.1	0.35	1.33	0.90
Ave Eff NO_3^--N	1.0	0.9	1.4	3.7	0.6	12.3	10.4	6.0	6.9
Eff Ca^{++}	—	—	—	—	69	48.0	52.4	41.2	41.1
Delta Ca^{++}	—	—	—	—	+ 33.0	+ 20.0	+ 21.6	+ 8.2	+ 5.1
Eff Hardness	225	224	220	218	185	219	196	156	155
Delta Hardness	+ 65	+ 82	+ 98	+118	+ 87	+ 96	+ 69	+ 19	+ 3
Eff Alkalinity	204	197	180	160	162	122	125	118	114
Delta Alkalinity	+ 75	+ 70	+ 59	+ 42	+ 1	+ 10	- 26	- 21	- 16
Eff Cl^-	27.5	28.8	31.2	35.0	29.7	29.8	29.0	26.3	24.8
Delta Cl^-	+ 1.8	- 5.1	- 5.5	- 12.3	+ 4.5	+ 0.5	+ 2.8	+ 0.9	+ 0.4
SS	16.0	14.8	21.7	21.0	22.0	21.0	18.8	14.0	13.8

TABLE A-26. CYCLE AVERAGES - BASIN 3 (YEAR 2) - SECONDARY EFFLUENT APPLICATION

	Beginning Date of Loading Cycle				
	9/6/77	11/1/77	1/10/78	3/21/78	6/13/78
Inf COD (Total)	68.9	84.2	65.1	79.9	57.7
Inf COD (Sol)	53.1	53.2	40.2	60.0	31.6
Eff COD	19.5	21.0	19.8	21.4	17.6
% Rem Total COD	71.7	75.0	69.6	73.2	69.5
% Rem Sol COD	63.3	60.5	50.7	64.3	44.3
Eff Total PO_4-P	1.84	3.0	4.4	3.7	1.32
% Rem Total PO_4-P	73.1	58.2	40.5	45.4	60.4
Ave Eff NH_4^+-N	0.71	1.4	3.4	2.6	6.0
Ave Eff NO_3^--N	7.9	7.8	5.6	9.1	7.9
Eff Ca^{++}	42.1	38.0	30.4	36.4	47.0
Delta Ca^{++}	+3.8	+9.2	+5.2	+1.4	+4.0
Eff Hardness	142	119	116	140	178
Delta Hardness	+17.2	+20.6	+34.4	+38.8	+6.3
Eff Alkalinity	110	103	117	118	145
Delta Alkalinity	-17.2	-4.5	-10.4	-22.0	-32.0
Eff Cl^-	24.5	25.8	29.5	27.4	25.7
Delta Cl^-	-1.4	+1.5	+5.2	+1.8	+2.7
SS	15.2	14.9	17.2	13.2	11.7

TABLE A-27. CYCLE AVERAGES - BASIN 3 (YEAR 3) - PRIMARY EFFLUENT APPLICATION

	Beginning Date of Loading Cycle					
	11/7/78	1/23/79	4/3/79	5/22/79	7/10/79	8/28/79
Inf COD (Total)	133	210	106	112	71.4	99.3
Inf COD (Sol)	68.5	106	38.2	43.9	31.0	44.7
Eff COD	14.1	21.1	15.0	11.1	10.8	10.9
% Rem Total COD	88.6	89.7	85.7	89.8	84.6	88.4
% Rem Sol COD	79.2	79.0	57.8	73.0	62.1	73.2
Eff Total PO_4-P	0.44	0.40	0.58	0.54	0.53	0.95
% Rem Total PO_4-P	91.0	94.3	81.2	74.2	72.1	69.7
Ave Eff NH_4^+-N	0.19	0.92	0.65	0.51	0.28	0.61
Ave Eff NO_3^--N	—	4.8	14.4	8.0	8.5	7.5
Eff Ca^{++}	70.5	63.0	71.3	80.4	68.7	60.4
Delta Ca^{++}	+ 14.0	+ 14.0	- 4.1	- 6.8	- 3.6	+ 2.2
Eff Hardness	231	231	249	291	262	208
Delta Hardness	+ 67.0	+ 51.5	+ 5.0	- 6.8	- 3.5	+ 2.7
Eff Alkalinity	105	107	108	135	133	133
Delta Alkalinity	- 60.0	- 81.0	- 60.0	- 64.0	- 43.0	- 32.7
Eff Cl^-	24.5	28.3	30.2	32.6	25.5	22.4
Delta Cl^-	- 3.0	- 1.5	+ 0.6	+ 6.0	+ 2.0	+ 0.8
SS	52.0	48.5	45.8	50.4	28.6	32.1